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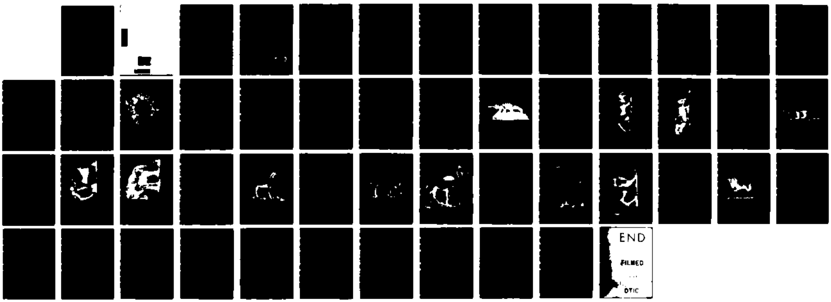

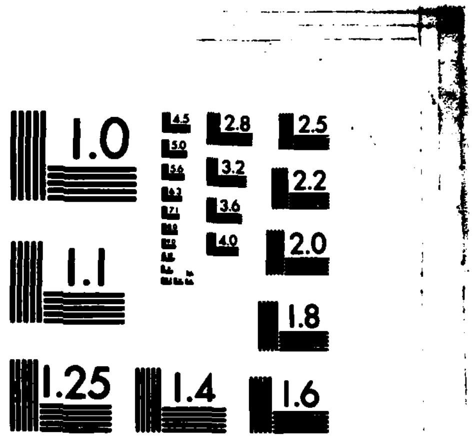

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides a look at the Ice Age climates, plants and animals of western Missouri as interpreted from fossil remains recovered from spring sites in the harry S. Truman Project area. The conclusion to be drawn from this look in the past is that the duration of one single set of climatic conditions, is short geologically. Prehistoric evidence from the last 50,000 years demonstrates that climates and the environments they fostered were episodic and subject to great change.

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ICE AGE CLIMATES, PLANTS AND ANIMALS OF WESTERN MISSOURI: A 50,000 YEAR RECORD OF CHANGE

by

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GLOSSARY OF TECHNICAL TERMS

anterior - toward the front; an anatomical term applied to the forward facing portion of a tooth, bone or skeleton; opposite of posterior.

aquifer - any porous rock body under the surface of the earth that contains ground water.

artesian - the term applied to ground water under sufficient pressure to rise above the aquifer containing it; when artesian water intersects the land surface, it is said to be an artesian spring.

chert - the insoluble residue left from the weathering and destruction of limestone; composed primarily of silica and occurring as inclusions in limestones; often occurring as a gravel, chert chokes many of Missouri's streams and forms a residuum on hill slopes and ridge tops.

conduit - the column, often gravel and sand-filled, through which water travels from the aquifer to the land surface and discharges as a spring.

coniferous - trees that have cones as a reproductive structure and which retain their leaves longer than a year, including such familiar forms as pines, spruces and firs; the evergreens; opposite of deciduous.

deciduous - plants that lose their leaves annually, including such familiar forms as oaks, hickories and maples; opposite of coniferous.

fauna - the animals of any place or time that lived in association with one another; a paleontologic fauna includes only those animals whose remains are preserved as fossils and which are found associated with one another.

feeder - the channel, often sand-filled, through which water travels through a conduit from the aquifer to the land surface and discharges as a spring; the feeder usually occupies the central portion of a conduit.

fissure - an extensive crack, break or fracture in the rocks; often occurring in limestones and produced by solution, fissures opening onto the surface of the ground are often filled with rubble and organic debris.

flora - the plants of any place or time that lived in association with one another; a paleontologic flora includes only those plants whose remains are preserved as fossils and which are found associated with one another.

fossil - the actual remains or simple traces of animals or plants that have been preserved by natural means in the earth's crust exclusive of organisms which have been buried since the beginning of the Recent era; fossils can therefore be remains or traces of still living as well as extinct organisms.

fossil assemblage - fossil plants and animals that are found together in one locality or fossil deposit.

genus (plural=*genera*) - a group of species ranked together based upon the determination of their common descent from a direct ancestor.

glacial - pertaining to a glacier; a glacial climate is a climate that is conducive to the development and growth of glaciers.

herbs - any seed plant whose stem withers to the ground after each season's growth and distinquished from trees or shrubs whose woody stems persist from year to year; including such familiar plants as sweet clover and wild sunflowers.

interstadial - pertaining to the time between glacial episodes; interstadial climate is a climate not conducive to the development and growth of glaciers.

invertebrate - animals without backbones; pertaining to all the major groups of animals exclusive of the vertebrates and including such familiar animals as insects, spiders and snails.

mammal - a warm blooded, generally hair-covered, vertebrate animal the female of which bears and nurses living young.

paleontology (paleontologic; paleontologist) - the scientific study of fossil remains of both plants and animals (pertaining to this study; one who undertakes this study).

peat - a dark brown or black organic substance produced by the partial decomposition and disintegration of plants that grow in marshes and similar wet areas.

phalanx (plural=*phalanges*) - in vertebrate animals, any of the bones comprising the toes and fingers.

Pleistocene - the so-called Glacial epoch or Ice Age; representing the last 3 million years of geologic time, exclusive of the last 10,000 years called the Recent.

pollen - the dust-like male sex cells of flowering plants; born from the flower by wind or carried by insects, pollen is deposited as a powder and can be, under proper conditions, preserved as fossils.

posterior - toward the rear; an anatomical term applied to the rearward facing portion of a tooth, bone or skeleton; opposite of anterior.

radiocarbon dating - the determination of the age of organic material by measuring the proportion of the isotope or variety C14 (=radiocarbon) in the carbon it contains; under usual conditions found in most radiocarbon laboratories the method is suitable for the determination of ages up to a maximum of about 40,000 years but some laboratories, under special conditions, can determine ages in excess of 70,000 years.

Recent - time and strata younger than the Pleistocene; Recent + Pleistocene = Quaternary.

reptile - a cold blooded, hairless, vertebrate animal that develops directly, without going through a gill-breathing larval stage, from an egg deposited by the female who generally provides no care for the hatchling.

sinkhole - a funnel-shaped depression in the land surface; often occurring in limestones as the result of subterranean cavern collapse; sinkholes are often filled with rubble and organic debris.

species - a group of interbreeding, morphologically similar plants or animals; for a paleontologic species, the criteria of interbreeding is inferred from degree of morphological similarity.

spring - a place where, without the influence of man, water flows from a rock or soil upon the land or into a body of surface water.

stratigraphic - pertaining to a stratum or strata.

stratum (plural=*strata*) - a single bed or layer of sediment consisting throughout of approximately the same kind of material.

terrace - a relatively flat, usually long and narrow, land surface paralleling a river or major stream and that is bounded on either side by steeper slopes; several terrace often occur together as steplike surfaces along rivers as the result of repeated episodes of cutting and filling of channels by rivers.

vertebrate - an animal with a backbone, more specifically an individual of the subphylum Vertebrata, a group of animals characterized by having a vertebral column, and a skeletal encasement for the brain (brain case or cranium).

INTRODUCTION

For the past 10 years I have been part of a research team working in Benton and Hickory counties, Missouri. This group of scientists has pursued a research program aimed at obtaining a better understanding of the geological and biological history of the western Missouri Ozarks. Prominent among the localities that contained evidence bearing on our objectives were three artesian spring sites that occurred, or still occur, along the Pomme de Terre River valley. This valley is one of the five arms or areas now comprising the Harry S. Truman Reservoir (Figure 1).

Specifically, I am a vertebrate paleontologist and the evidence of most interest to me has been the remains of fossil vertebrate animals, many of which are now long extinct, recovered from these localities. During the summers of our activities in the reservoir area, numerous people visited our excavations. These visitors were drawn by an interest in Missouri's Ice Age inhabitants and by a rare opportunity to observe, first hand, excavations aimed at exposing and recovering fossil animal remains. Few visitors left disappointed. As one bone was removed, generally several others appeared for the first time and so numerous large bones of extinct animals were on continuous display.

The purpose of this booklet is to summarize the results of our decade of work in the spring sites. In so doing, the reader will be introduced to the climatic changes that affected western Missouri during the last 50,000 years and to the vastly different environments and, especially, animals that these highly variable climates fostered.

Geology

The spring sites that contained the fossil remains occurred in terraces that bordered the Pomme de Terre River valley. These terraces were formed during the Pleistocene or Ice Age and represent previous high river levels. At different times and places during the formation of these terraces, water under pressure worked its way to the surface of the ground to form numerous artesian springs. Most of these ancient springs are now dry and are deeply buried without present-day traces. Others, however, though considerably diminished, persisted and are represented by low, marshy areas in the river bottomlands (Figure 2). It is within deposits laid down thousands of years ago in these persistent springs that our excavations were conducted and within which the remains of many now extinct animals occurred.

A spring site locality

Boney Spring in Benton County is an example of the type of locality from which the western Missouri Ice Age fossil record has been obtained. Deposits encountered during the excavation of this locality were a sequence of clays and peats (Figures 3 and 4). The clays were deposited as mud and fine silt

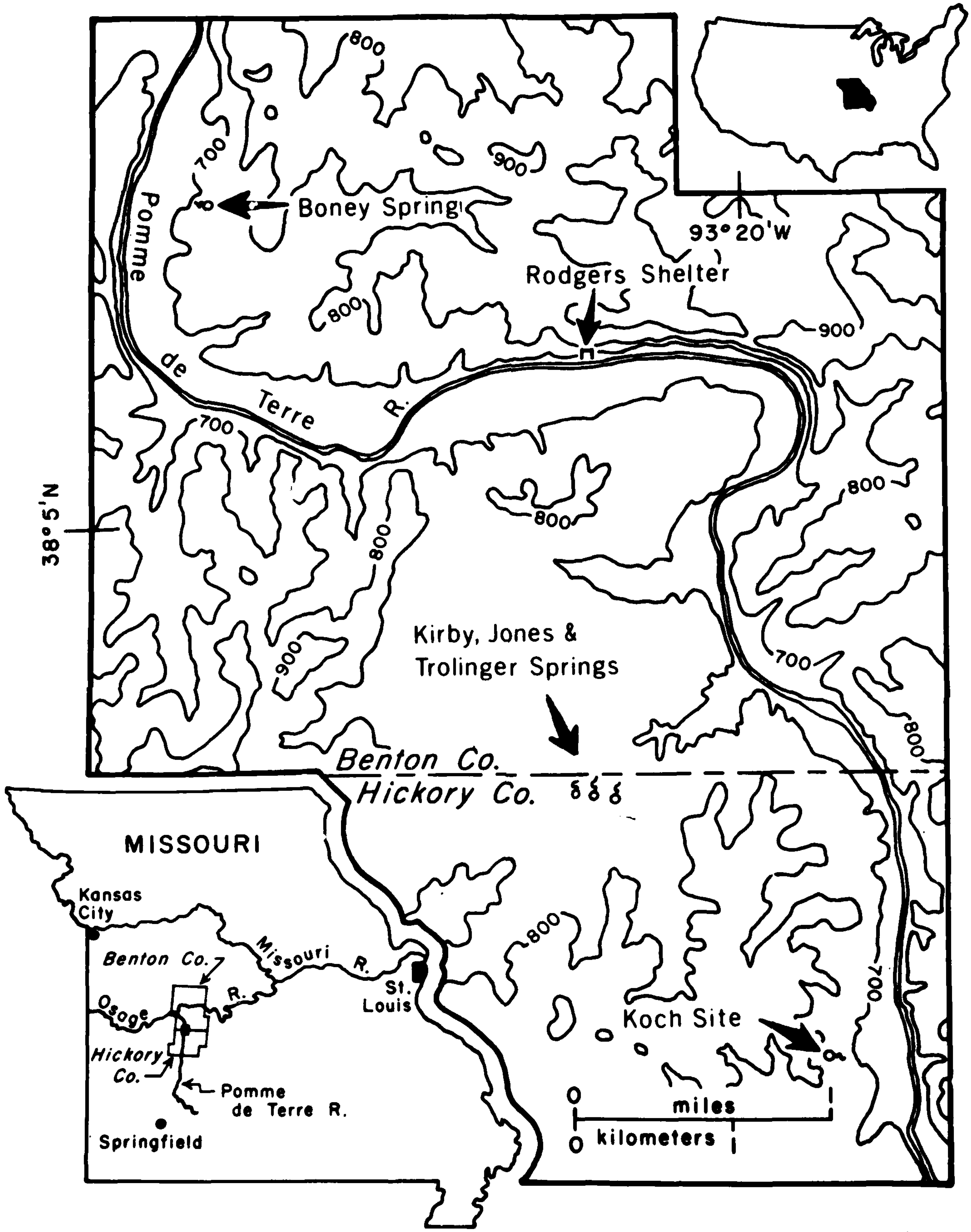

Figure 1. Map of the lower Pomme de Terre River valley in Benton and Hickory counties, Missouri showing the location of sites mentioned in this booklet.

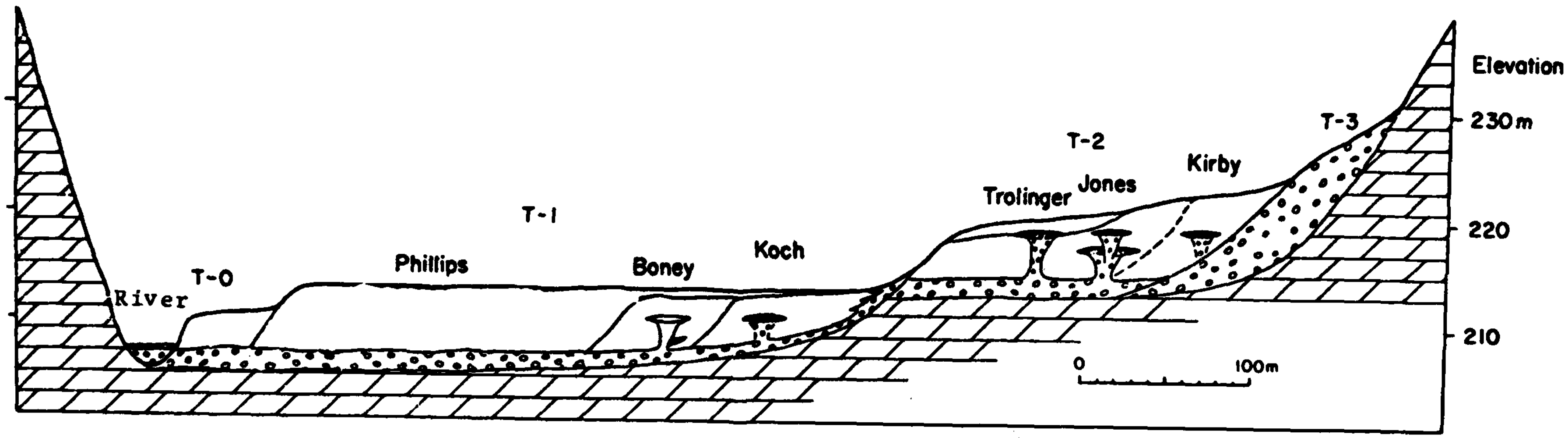

Figure 2. Cross section of the lower Pomme de Terre River Valley showing the relationship of Trolinger, Jones, and Boney Springs to terraces and other buried spring sites. T-0 represent the terrace most recently formed and T-3 is the oldest.

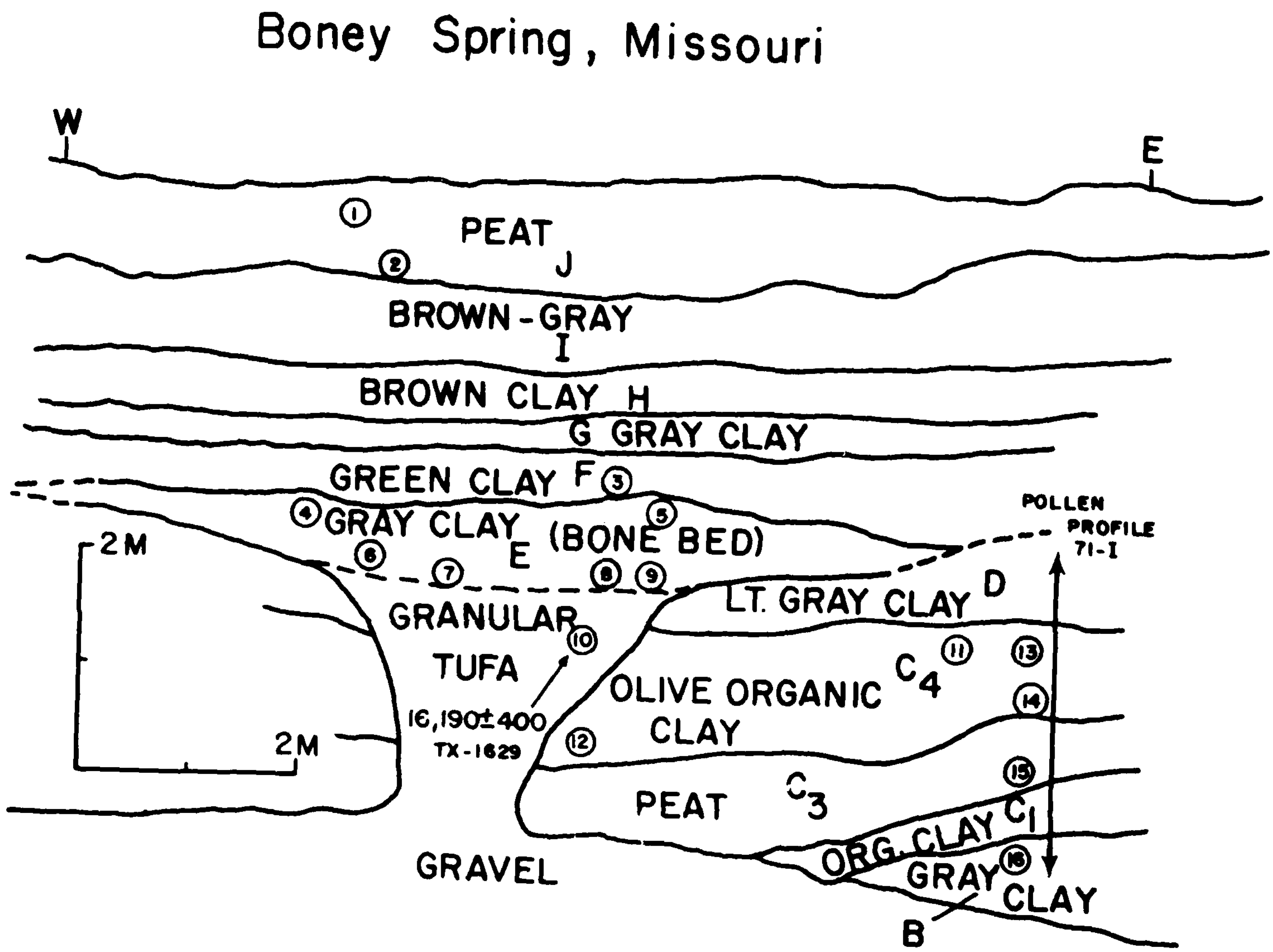

Figure 3. Cross section of Boney Spring. The circled numbers correspond to the radiocarbon age determinations from Figure 4. The stratigraphic column (Figure 4) does not include the grandular tufa (volcanic rock) and its associated radiocarbon date.

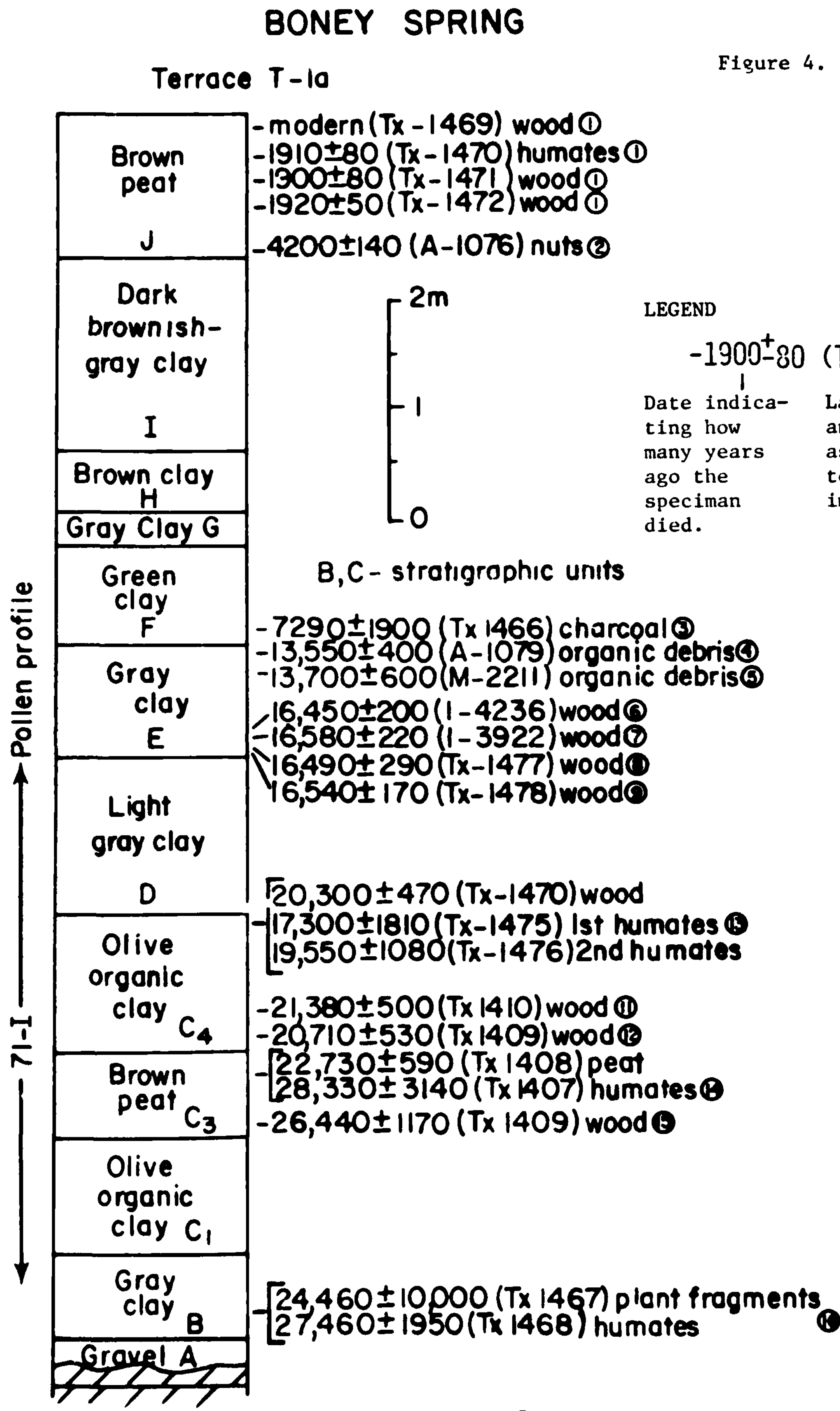

Figure 4. The stratigraphic column from Boney Spring and radiocarbon age determination.

LEGEND

-1900±80 (Tx-1471) WOOD①

Date indicating how many years ago the speciman died.	Laboratory and number assigned to speciman tested.	Type of speciman.

by the Pomme de Terre River during past periods dominated by flooding and presumably indicate wetter conditions. Deposited in this manner, the clays represent the slow build up of the terrace itself. The peats on the other hand are akin to marsh soils and developed during times of non-flooding and presumably indicate only moist and climatically more stable conditions. During these periods, presumably each several thousands of years in duration, plants grew, died, decayed and were replaced in what was a normal and natural succession in and around the spring. Peat represents the vegetation mat produced during this succession and consists primarily of plant remains. Boney Spring's history has been studied in considerable detail and from this has come a well documented, reasonably well understood, picture of past events that have transpired there.

For purposes of our example, the following series of events can be interpreted from the sedimentary layers and from the determination of their radiocarbon ages: 1) reworking of older terrace gravel before 28,000 years to form the aquifer for spring activity; 2) a period of clay deposition and terrace building from 28,000 to 26,000 years ago; 3) a period of stability and peat formation from 26,000 to 23,000 years ago; 4) a second period of clay deposition and renewed terrace building from 23,000 to 20,000 years ago; 5) a second period of stability and moss mat formation from 16,500 to 13,000 years ago; 6) a third period of terrace building from perhaps 9000 to 4200 years ago; and 7) a third and Recent period of stability and peat formation from 4200 years ago to the present.

Of this series, the 5th and 6th relate directly to the fossil record. Sometime after 20,000 years ago, the spring under pressure worked through the clays represented by the second period of terrace building and emerged upon the ground surface. Here a pond formed, trees and a moss mat grew and presumably animals came to water. At approximately 16,000 years ago discharge to the spring was disrupted and a decrease in flow occurred. The environment became dryer, organic mat vegetation ceased to develop and began to decay and animal visitation at the site became more intense. The climatic factor that seems to tie these events together best is drought, at first perhaps unpronounced and unnoticed but growing in intensity and by 13,500 years ago becoming extremely severe. It was during the severe stages of this drought that the remains of animals accumulated in and around the spring. By this stage Boney Spring had diminished to a mere trickle of water that quickly evaporated at the surface. During this interval, based on the evidence of the bone bed in Boney Spring, large numbers of animals, particularly mastodons and ground sloths, were attracted to the locality and it was here, 13,500 years ago, that many of them perished. Their remains lay littered on the surface of the ground around the spring until buried in clay by the third and final phase of terrace building no later than 9000 years ago (Figure 5).

Time

The time frame of our research program in western Missouri encompasses the last 50,000 years. Deposition of sediments and organic remains in spring sites may have been continuous throughout this interval. However, if this was so, the vast majority of these springs lie buried and undiscovered. Those we have discovered and excavated and for which prehistoric events have been inferred add up, not to a continuous record, but to one that is punctuated. In this sense the major source of our knowledge of this rec-

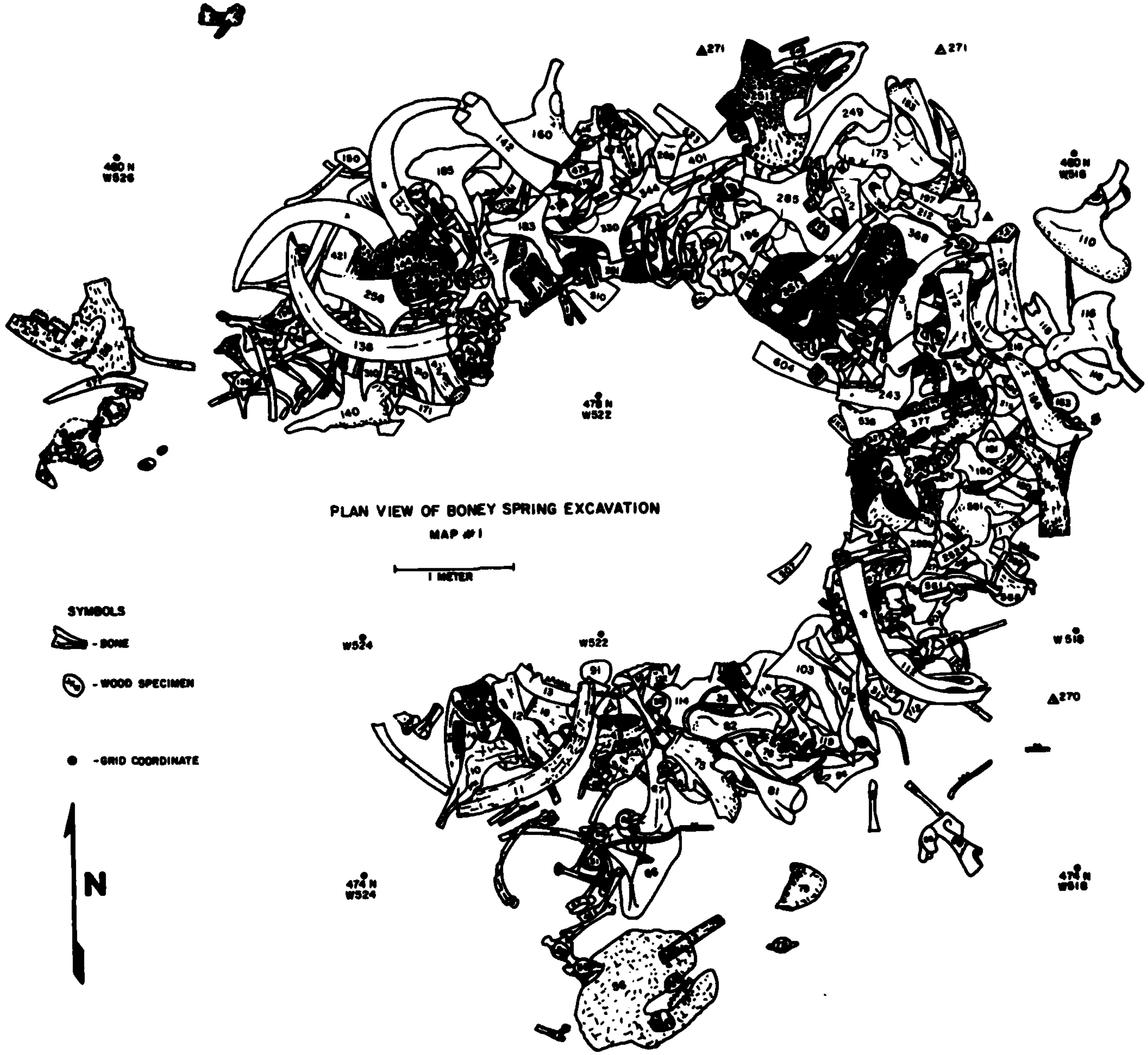

Figure 5. Bird's-eye view of the Boney Spring bone bed. The specimens occurred like "logs in a jam" centered about the spring feeder.

ord can be likened to having the contents of four time capsules of known approximate but different ages before us, each containing prehistoric relics (Figure 6).

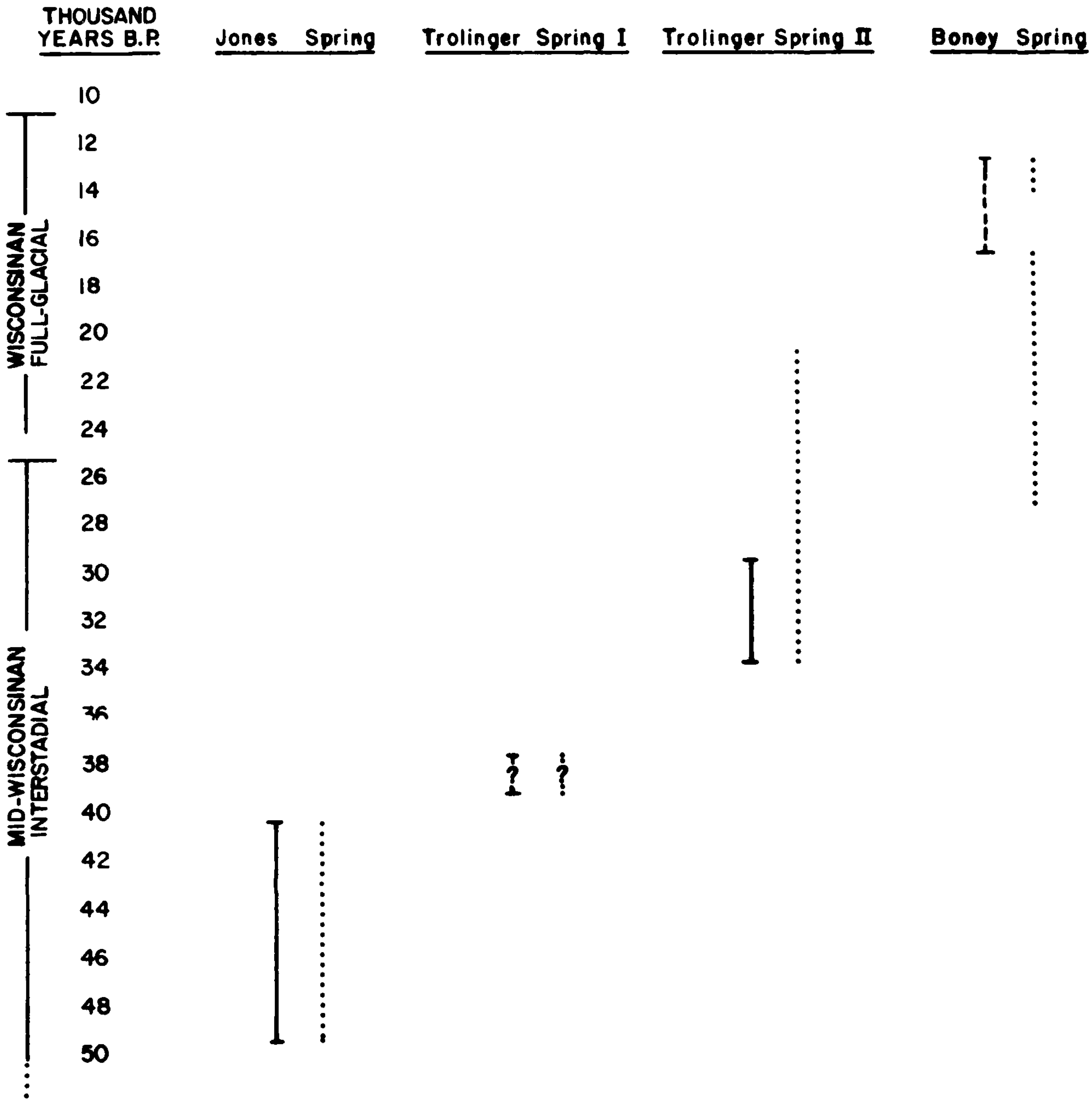

Figure 6. The duration of biological events recorded in spring site fossil assemblages from western Missouri. Solid line= animal record; dotted line= plant record; dashed line= possible limits. Trolinger Spring I is the fossil assemblage from the gravels and Trolinger Spring II is the fossil assemblage from the peat. Wisconsinan is the term applied to the last glacial period that extended from 75,000 to approximately 11,000 years ago.

THE CLIMATE

Perhaps more than any other phenomenon, the spring site fossil assemblages from the Pomme de Terre River valley reveal the considerable magnitude of climatic change during the last 50,000 years.

Jones Spring reveals that a mild, deciduous environment, probably both milder and more moist than today's, supporting alligators, mastodons and Giant bison, existed in western Missouri 49,000 years ago. At this time western Missouri looked much like portions of the southeastern United States do today. Before 40,000 years ago, however, this warm, moist deciduous environment had given way to one that was dominantly cool, dry and coniferous. During this later time an open pine-woodland, containing some deciduous species such as oak, occupied the western Missouri landscape. Though the alligator had disappeared from western Missouri by this time, the environment was still inhabited by mastodons and supported, in addition, large grazing ground sloths, mammoths and large forms of bison. At this time, sometime before 40,000 years ago but after 49,000 years ago, western Missouri looked much like southern Michigan does today.

The record contained in Trolinger Spring gravels and possibly that in Kirby Spring peat as well began to accumulate during a time when a deciduous environment had returned to western Missouri perhaps around 38,000 years ago. Unlike the earlier deciduous environment that supported forests and alligators, this one was dryer and probably somewhat cooler. Bear, mammoth, horses, deer and large but, relative to former times, smaller forms of bison inhabited western Missouri at this time. The known or inferred habitat preferences of these animals indicate that while some sparse woodland may have occupied the river bottomlands and especially the margins of springs during this time, the western Missouri landscape was dominated by open grasslands. During this interval western Missouri was quite like the western plains of Oklahoma and Kansas today. The fossil assemblage contained in the peat in Trolinger Spring signals yet another episode of climatic change. As has been mentioned this episode may be represented in the Koch Spring peat as well. By this time, 34,000 years ago, the climate had grown cooler and more moist and pine-woodland reappeared on the western Missouri landscape. This environment supported mastodons in great numbers as well as Stilt-legged deer and Woodland muskoxen, but apparently few other large animal species. At Koch Spring, perhaps at this time, perhaps somewhat earlier or later, mastodons, deer and perhaps muskoxen as well were associated with several forms of large ground sloths. Once again, western Missouri looked much like southern Michigan does today.

This climate and resulting environment seem to have stabilized in western Missouri and it is not unil 8,000 or 9,000 years later than another episode of change is revealed in spring site fossil assemblages. However, between 25,000 and 20,000 years ago the pollen record from western Missouri indicates a dramatic change in climate and vegetation. In sediments spanning this interval in both Trolinger and Boney springs, and probably in those

in Koch Spring as well, there is an abrupt shift from pine and herbs to spruce dominance. Before this shift spruce had been essentially absent, but by about 23,000 years ago spruce first appears and, within a short vertical sampling distance, percentages as high as 60 to 90% occur in Trolinger and Boney springs sediments. This shift reflects the climatic shift from cool interstadial to cold glacial conditions. Based on pollen data the early part of this transition must have been the coldest period during the last 50,000 years in western Missouri. During this period spruce dominated the landscape. The glacier front itself did not enter Missouri during this period but did extend to a position about 400 km (=250 miles) to the north of the Pomme de Terre valley. Regrettably, this period is not represented by animal remains from spring sites in western Missouri. For whatever reason(s), the faunal record during this interval, and presumably earlier glacial episodes as well, is commonly recovered from sinkholes, fissures or caves, or from other non-spring depositional environments. This record is dominated by the remains of small animals, often rodents, that today have distributions far to the north in Arctic Canada.

The record of changing climates is next met in Boney Spring 13,500 years ago. Here a large and diverse fauna, dominated by mastodons and ground sloths, is associated with the rapid development of warm conditions that caused the glacial spruce forest to collapse and that signaled the beginning of today's oak-hickory Ozark forest. As previously discussed, the extinction of mastodons and other typically Ice Age animals coincided with this general, rapid and pronounced warming and it is to be concluded from the evidence that the two events, climatic warming and animal extinction, were cause and effect, respectively.

THE ANIMALS

This section contains a brief discussion of the more interesting, unexpected and significant fossil vertebrates recovered from the spring sites in the Harry S. Truman Project area. Included here are those animals recovered from these sites that are recorded for the first time in the Pleistocene of Missouri as well as those that play the greatest role in revealing the magnitude of climatic changes that have affected Missouri during the last 50,000 years.

The discussion of each species or form is accompanied by a reconstruction of the animal's probable appearance in life as drawn by Mr. William C. Stone and reproduced here courtesy of the Illinois State Museum. In the instance of the Stilt-legged deer, *Sangamona fugitiva*, this represents the first attempted reconstruction of this animal's appearance, made possible in light of fossil antler material recovered from Jones Spring.

Reptiles

Turtle remains were found in Trolinger and Jones springs but were particularly abundant in the latter, where numerous remains of an extinct large variety of Box turtle were recovered. Boney Spring lacked turtle remains but contained snake remains in considerable diversity and some abaundance. Most unexpectedly, Jones Spring also contained the remains of American alligators.

Today the American alligator, *Alligator mississipiensis* (Figure 7) inhabits the great river swamps, lakes, bayous and marshes of Florida and the Gulf and lower Atlantic Coastal plains. In very recent times, including the Colonial era, the American alligator ranged from North Carolina south to the Florida Keys and west through southern Arkansas and southeastern Oklahoma to central Texas. In 1940 alligator fossils were reported to have been recovered from a fissure in Jefferson County, Missouri, in association with the remains of other animals. The fossils from Jones Spring, consisting of a skull fragment and terminal phalanx of a small individual or individuals and 6 teeth representing an adult perhaps 3 meters in length (based on comparison with Recent alligator teeth and skeletons), provide the first evidence of this species in the Osage River basin. In addition these fossils represent the northwesternmost occurrence of this species in the Pleistocene fossil record of North America. They demonstrate quite forcefully that the winter climate of western Missouri 49,000 years ago was much milder than today's.

Birds

Bird remains are rare in spring sites in western Missouri. Remains of both surface-feeding and diving ducks occurred not unexpectedly in Jones Spring which contained a diverse fauna including other aquatic forms.

Figure 7. The American alligator, *Alligator mississipiensis*. Fossils representing two individuals were found in Jones Spring. Length of individual shown is 10 feet.

Mammals

Order Edentata

Living anteaters, tree sloths and armadillos belong to the order Edentata, meaning without teeth, though this feature only characterizes the anteater. Rather, most of the edentates have simple, peg-like teeth that in most fossil and in all living forms lack enamel.

Pleistocene fossil edentates occur in a wide diversity and in considerable abundance throughout South, Central and North America. In western Missouri, large extinct ground sloths seem particularly well represented in the Ice Age fossil record and at least two species are known. Among living animals, the extinct ground sloths are most closely related to the tree sloths of Central and northern South America. Ground sloths are not native to North America but have their ancestry in South America and arrived here relatively recently, geologically speaking, as immigrants.

Harlan's ground sloth, *Glossotherium harlani* (Figure 8), is represented in the fossil assemblages from both Jones and Boney springs. In addition remains of this species as well as a larger form were recovered in 1840 from Koch Spring. In western Missouri this animal was probably a grazer in bottomland openings occurring within forested conditions. Elsewhere in North America Harlan's ground sloth ranged from the Atlantic to the Pacific coast and from Florida to Washington during the middle and late Pleistocene. It is a common animal in the "tar pits" at Rancho La Brea, Los Angeles County, California. Presumably slow and offering great bulk--4 feet high and 6 feet long, the animal must have weighed nearly a ton--Harlan's ground sloths were probably preyed upon by the great cats of the Pleistocene.

Order Rodentia

Small rodents are rare in fossil assemblages recovered from spring sites in western Missouri. This is presumably due to their light weight and ability to scamper rapidly and warily. The Boney Spring bone bed did contain the remains of several rodent species but none in great abundance. More interesting, perhaps, is the record of large rodents from these spring sites.

The first evidence of the Giant beaver, *Castoroides ohioensis* (Figure 9), in Missouri was two incisor teeth recovered from Boney Spring in 1968. In 1971 another specimen, a portion of one of those recovered earlier, was found in Boney Spring and in 1976 a molar tooth of this animal was recovered from Jones Spring. These 3 teeth represent the entire collection of remains of this animal known from Missouri! Elsewhere in North America, the Giant beaver is known from Pleistocene deposits from New York to Florida and westward to western Nebraska; there is a single record known from Oregon. The Giant beaver inhabited forested areas with a cool, humid climate. It was closely associated with extensive lakes, ponds and swamps of the Pleistocene.

Unlike the modern Canadian beaver to which it is closely related, the Giant beaver did not topple trees or build dams. Its long, protruding lower incisors do not end in the sharp chisel edge that characterizes the modern beaver tooth but rather terminate in blunted points that seem ideally suited for rooting up vegetation from pond bottoms. Relative to the living beaver, the Giant beaver possessed shorter front legs and larger hind feet. These suggest that the Giant beaver was more at home in the water and less

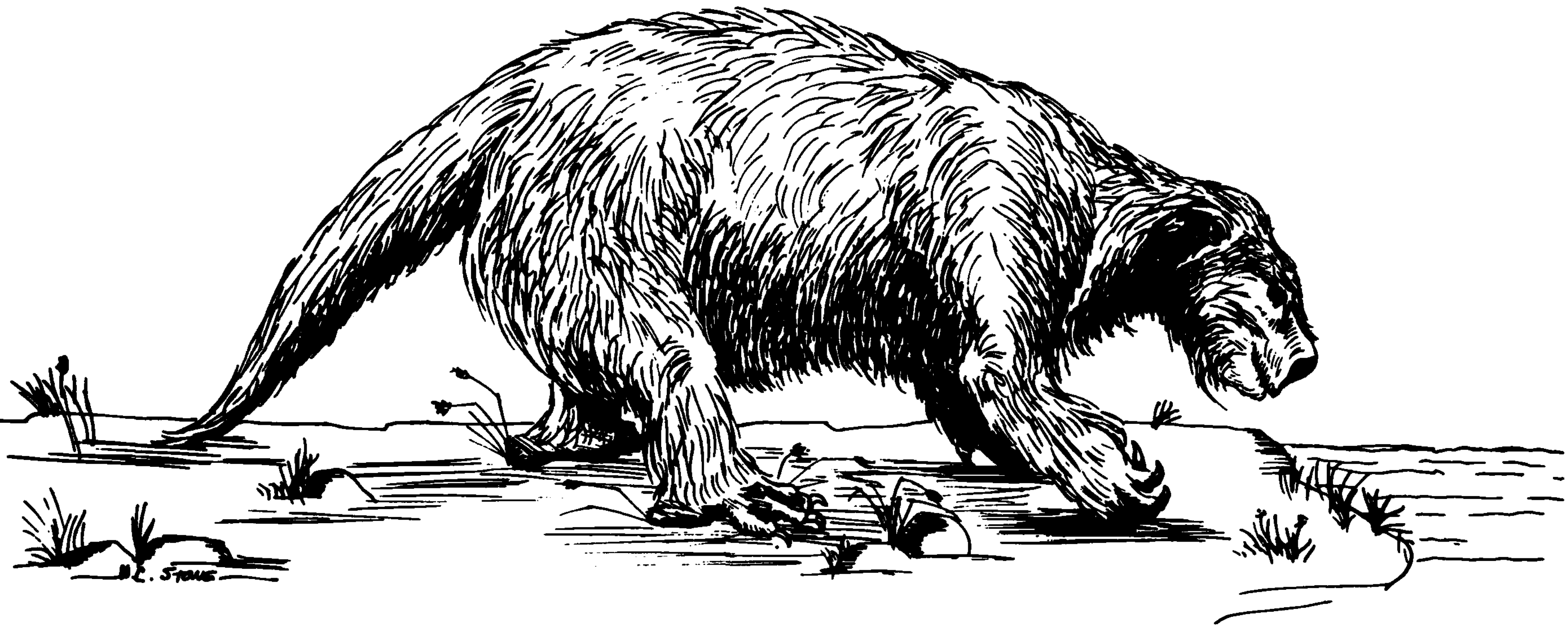

Figure 8. Harlan's ground sloth, *Glossotherium harlani*. This was a common inhabitant of western Missouri during the late Pleistocene. Remains of Harlan's ground sloth have been found in Jones and Boney springs. Length of individual shown is 8 feet, with a height of 4 feet.

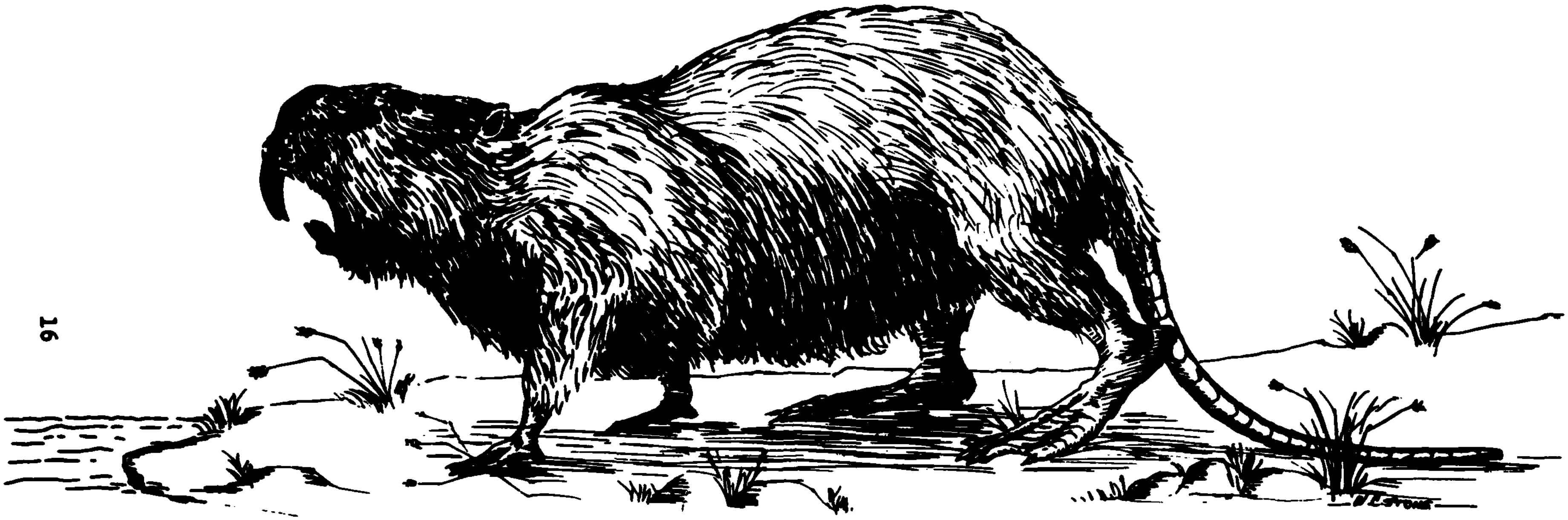

Figure 9. The Giant beaver, *Castoroides ohioensis*. In Missouri the Giant beaver is known only from fossils found in Jones and Boney springs. The head and body length of the individual shown is 4 feet, with a height of 2.5 feet. Adult Giant beavers probably weighed 300-400 pounds.

at home on the land than is the modern beaver. The tail appears not to have been broad and flat but rather more thin and rounded, like that in the living muskrat. The Black bear size and beaver-like bulk of the animal make it one of the largest rodents known to have existed.

Order Carnivora

Carnivores are rare in fossil assemblages recovered from spring sites in western Missouri. This is perhaps surprising, given the numerous large potential prey animals that congregated around springs during former times. However, carnivores are by their nature wary and careful and presumably this accounts for their rarity in these localities.

A single raccoon tooth was recovered from Boney Spring. This single specimen represents the total carnivore collection recovered from among the remains of 31 mastodons. This unexpected situation is underscored by the fact that the raccoon is only marginally carnivorous as well as by the fact that the Boney Spring mastodons and other large animals accumulated rapidly and catastrophically, with numerous congregating animals in either decrepit or in poor condition. This is a situation usually exploited by large mammalian carnivores.

Three teeth recovered from Trolinger Spring are referred to a young individual Extinct black bear, *Ursus americanus amplidens*. Though bears are nominally carnivores most species, including Black bears, are actually omnivores and several are strict vegetarians. Again, the presence of only a marginally carnivorous carnivore among the remains of mammoths, horses, deer and bison is rather unexpected. Except for larger size, the Extinct black bear was very much like the living Black bear.

The presence of alligators in Jones Spring has already been discussed. Not unexpectedly, given the lesson previously learned at Boney Spring, the tooth of a raccoon was recovered in Jones Spring in 1975. The following year, the same year during which the alligator remains were first encountered, a humerus referred with certainty to a juvenile Sabertooth, *Smilodon* cf. *floridanus*, was recovered from this locality. The Sabertooth (Figure 10) is precisely the carnivore that would be expected to occur in spring site fossil assemblages, based on our knowledge of its habits and behavior. Taking its name from the saber-like upper canines that measured greater than 10 inches in length and that protruded from the jaws at least half of that length, these lion-sized, cat-like animals are often considered to be a highly specialized predator of mastodons, mammoths and other now extinct thick-skinned animals of the Pleistocene. Physically short and muscular, with great strength and agility, the Sabertooth was among the most formidable of mammalian predators. Behaviorly, it is thought that the Sabertooth, like the modern lion, formed prides to better stalk prey in open habitats.

Though this is the first record of the Sabertooth from western Missouri, the species is known from localities in eastern Missouri. Elsewhere, the Sabertooth was abundant throughout North America during the late Pleistocene. Records of this species occur from Florida to California and from Alaska to central Mexico.

Order Proboscidea

The order Proboscidea includes two species of living elephants, the one in Asia, the other in Africa, as well as a tremendous variety of extinct

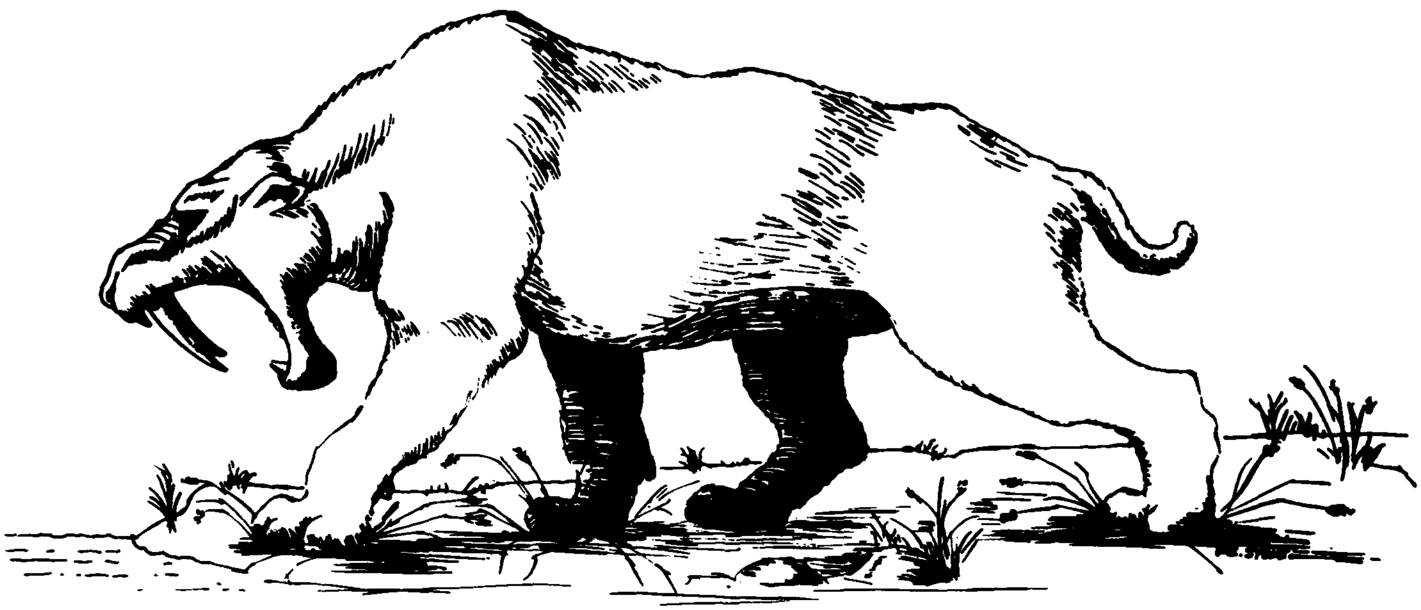

Figure 10. The Sabertooth, *Smilodon floridanus*. A single specimen that compares favorably with the Sabertooth was recovered from Jones Spring. The length of the adult individual shown is 6 feet, with a height at the shoulder of 3 feet.

species of true elephants, mastodons and mastodonts. The hallmark of this order is the proboscis, or trunk, a feature whose presence is evidenced in fossil, extinct forms by certain modifications of the skull. Going hand-in-hand with the trunk in this order, and perhaps in a sense necessitating its development, are the tusks, which are much enlarged incisor teeth. Two fossil proboscideans figure prominantly as fossils in western Missouri spring sites--the American mastodon and Jefferson's mammoth.

The American mastodon, *Mammut americanum* (Figure 11), is one of the most common fossil vertebrates found in Pleistocene deposits throughout North America. It occurs from the Atlantic to the Pacific coasts and from the vicinity of Mexico City to Alaska.

The fossil record contained in western Missouri spring sites is dominated by mastodons and to date the remains of 71 individuals have been excavated from Trolinger, Jones and Boney springs. Mastodons were large, powerful animals with elephant-like builds. Unlike living elephants, however, or their extinct close relatives the mammoths which are or were predominantly grazers, mastodons were browsers occurring abundantly in pine woodlands and spruce forests throughout North America during the late Pleistocene. Mastodon means, literally, nipple- or breast-tooth, a name taken from the characteristic side-by-side arrangement of the major cusps comprising the molar tooth. During the 18th century, these large teeth with their pointed, often sharpened, cusps were thought by many scientists of that day to be suited to flesh-eating and thus the mastodon was considered to be a carnivore. However, it was pointed out during the late part of the 18th century by Benjamen Franklin and others that an animal with an elephant's body, such as the mastodon, would be a ponderous, inept and absolutely preposterous carnivore. Today we interpret, we assume correctly, these teeth to be ideally suited to chewing a diet of coniferous branches, twigs and needles and probably other plants as well.

Like those of mastodons, mammoth remains (genus *Mammuthus*) are common fossils found occurring in middle and late Pleistocene deposits throughout North America. In the southwestern United States mammoths are frequently formed associated with the remains of other grazers, notably horses and bison. A similar association exists in the gravels deposited in Trolinger Spring in the Harry S. Truman Project area. In addition, however, mammoth remains in nearby Jones Spring indicate that in parts of Missouri at least during certain periods mammoths were associated with browsers, notably mastodons.

The mammoth remains from both Trolinger and Jones springs belong to the species *Mammuthus jeffersonii* (Figure 12), named after Thomas Jefferson, the third President of the United States. Jefferson's mammoth was widespread across the generally northern portion of the United States during the late Pleistocene. The species has been reported from Alaska and the Pacific Northwest to Montana and the western and central Great Lakes region to New York.

Fossils of mammoths are not commonly found in Missouri. The fossils of Jefferson's mammoth from Trolinger and Jones springs in the project area are the most important collections of mammoth remains currently known to exist from Missouri.

Like their close relatives the living elephants, mammoths were primarily grazers. They lived in herds numbering perhaps 5-15 individuals each and inhabited open grasslands or, frequently, glades in river bottomland forests. Mammoth teeth are complex structures comsisting of numerous vertical plates bound together by a substance termed cement. Each plate has an inner core of dentine and is enclosed by enamel. As the tooth erupts and begins to wear,

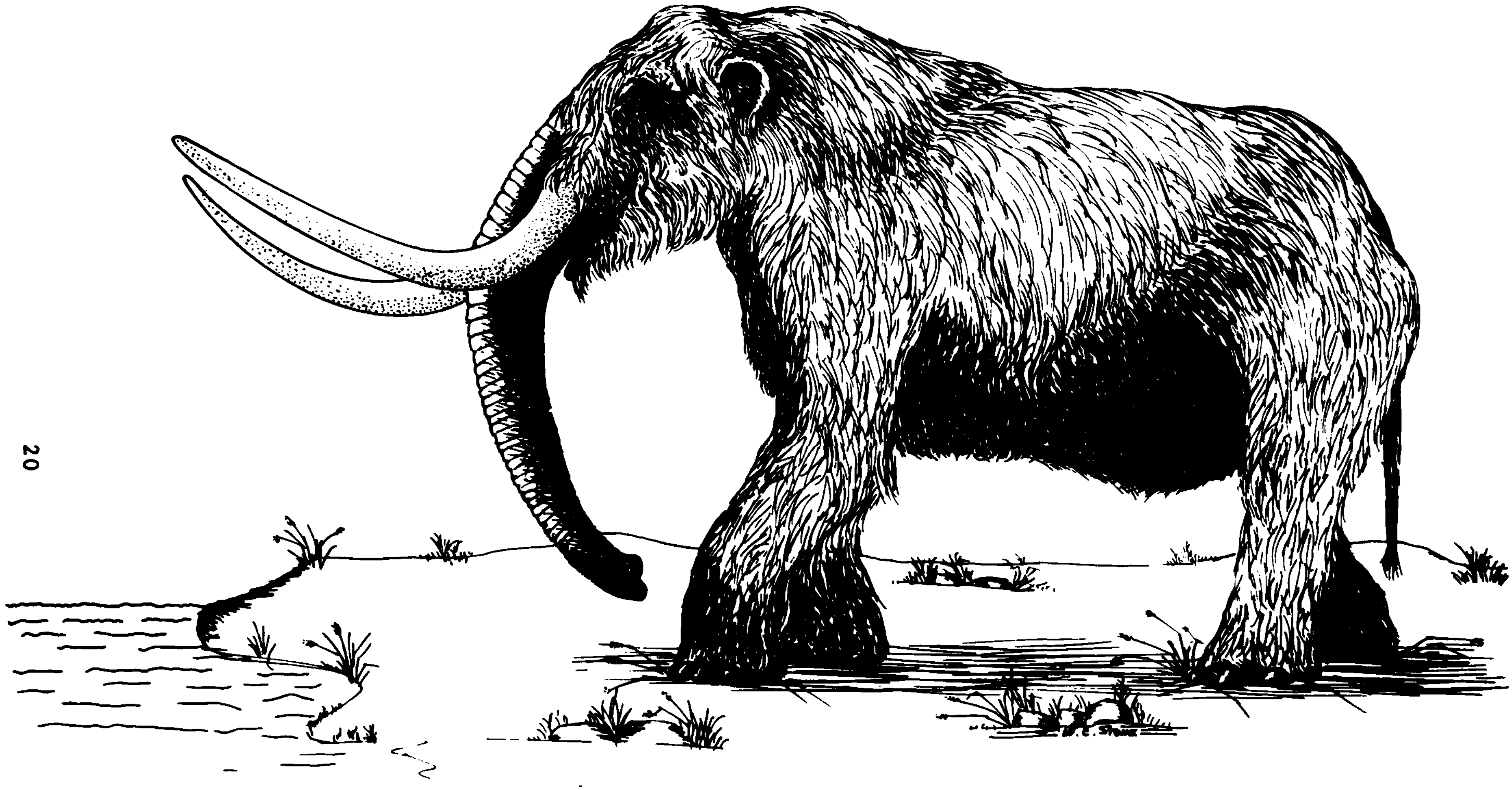

Figure 11. The American mastodon, *Mammut americanum*. The American mastodon was the most abundant mammal occurring in late Pleistocene spring site fossil assemblages in western Missouri. The individual represented was 17.5 feet in length from tip of tusks to tail and had a shoulder height of 9 feet.

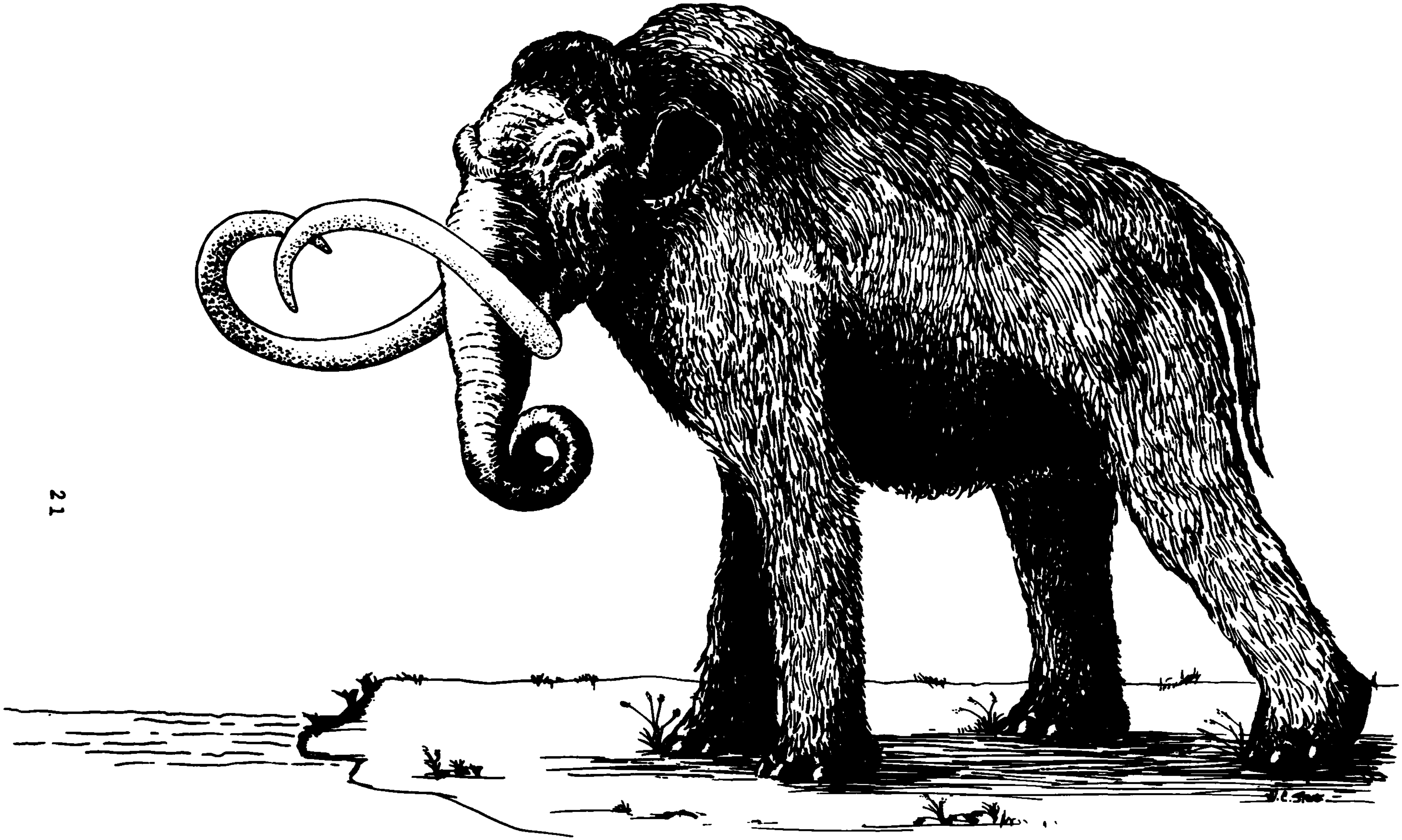

Figure 12. Jefferson's mammoth, *Mammuthus jeffersonii*. Remains of Jefferson's mammoth occurred in Trolinger Spring gravels and in Jones Spring peat. The individual shown measured 17.5 feet in length from tip of tusks to tail and had a shoulder height of 12 feet.

a rasp-like chewing surface develops, producing a repeating sequence of thin transverse ridges composed of cement-enamel-dentine-enamel, etc. The rasp-like chewing surfaces of mammoth teeth are ideally suited for a diet of grasses.

Mammoths were generally taller and perhaps not as long, head to tail, as mastodons. In addition they were generally of a lighter build. In spite of these differences, however, a large mammoth and a large mastodon probably weighed approximately the same, i.e., 5-6 tons.

Order Perissodactyla

The order Perissodactyla was formerly much more diversified and numerous. Today, the order Perissodactyla contains only 8 species of horses or horse-like animals, 4 species of tapirs, and 5 species of rhinoceroses.

Living and extinct perissodactyls, a term meaning odd-toed, have a characteristic foot in which the central, or third, toe is emphasized and the others reduced. Perissodactyls are medium to large sized hoofed mammals adapted to running. Among the perissodactyls, horses and tapirs figure importantly as late Pleistocene inhabitants of western Missouri.

Among the most interesting and unusual fossils obtained from the spring sites in the project area were the two halves of a lower jaw and most of the upper teeth of one individual onager-like horse, *Equus calobatus* or *Equus hemionus* (Figure 13), from Jones Spring. Living onagers, of the species *Equus hemionus*, are ass-like horses most frequently found in desert plains covered with a low shrub vegetation. Their present distribution includes the steppes of Mongolia, southward to Tibet and Syria, and the north and east portions of Africa. Extinct (e.g., *Equus calobatus*) as well as living onagers had a wide distribution on the High Plains of North America throughout the Pleistocene. Onagers are seaparated from other horses on the basis of skull and lower teeth characters as well as on the basis of their long and slender limbs. With these long, slender legs, light build and minimum food and water requirements, onagers are better suited to more rigorous habitats than are other species of horses.

Based on specimens recovered from Jones Spring, it is not possible to determine precisely which of two onager species was represented. *Equus calobatus*, the extinct Stilt-legged onager, was relatively common throughout the Pleistocene in western North America and records are known from Texas, Oklahoma, Kansas and Nebraska. *Equus hemionus*, the living Onager, still survives in Asia but occurred in North America (Alaska, Texas) and Eurasia during the Pleistocene. The teeth in the jaw halves from Jones Spring have a dental pattern and are of a size that together are like *Equus hemionus* but which in terms of dental pattern alone compare as well with *Equus calobatus*. In the absence of more certainly identifiable specimens from Jones Spring, e.g., limb bones or additional jaws, it is not possible to determine specifically which onager is represented. Nevertheless, the Jones Spring onager was an unexpected discovery and represents the first record of this type of horse from Missouri.

There is a single living genus of tapirs, *Tapirus*, containing four species. *Tapirus terrestris* and *T. roulini* inhabit South America, *T. bairdii* ranges from Central American into southern Mexico, and *T. indicus* occurs in southeastern Asia.

Today tapirs live in wooded or grassy areas near permament sources of water. They conceal themselves in forests and thickets during the day and

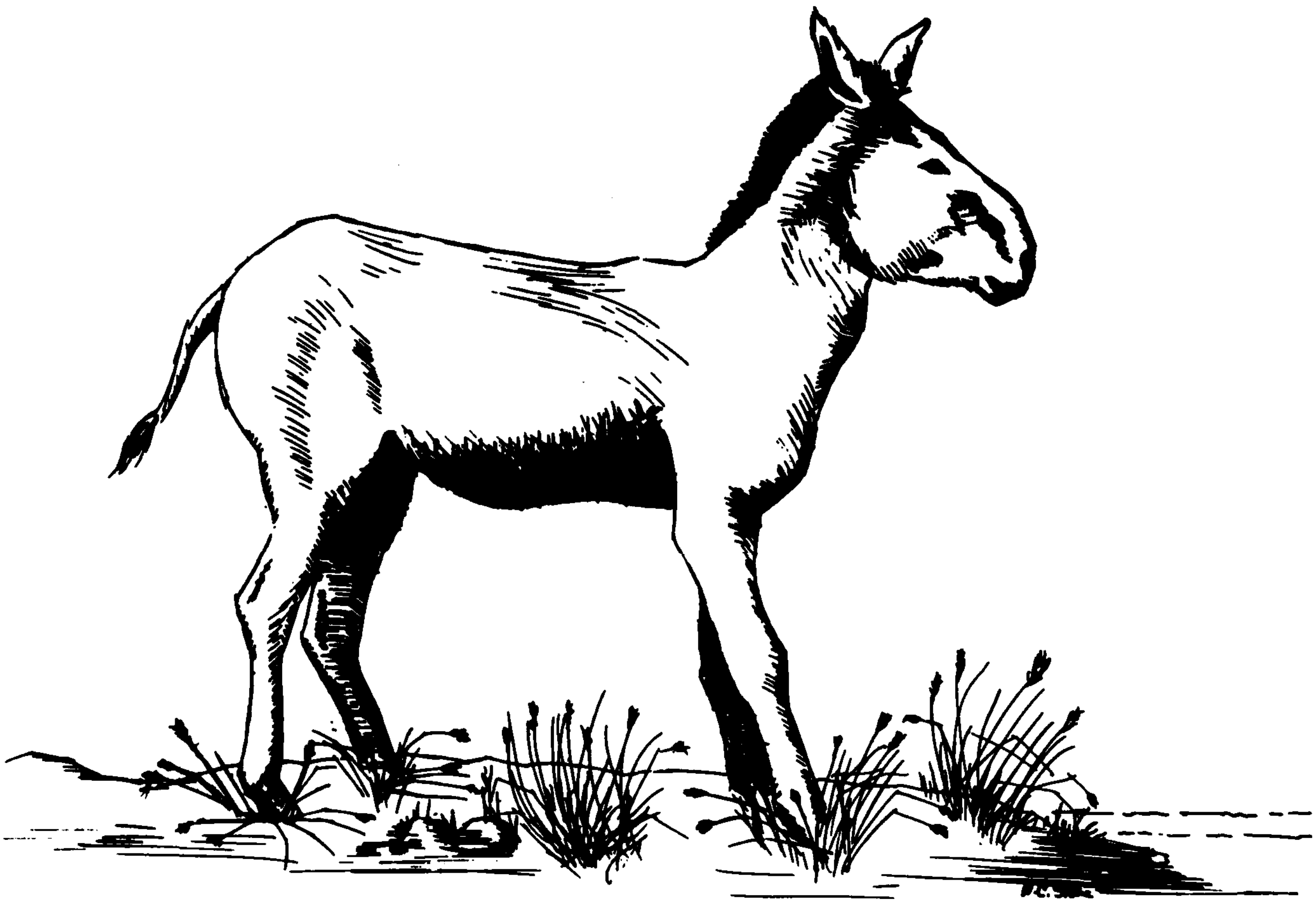

Figure 13. Onager, *Equus hemionus*. Onager remains, perhaps of *Equus hemionus*, the living Onager of central Asia and northeast Africa, perhaps of the extinct form *Equus calobatus*, occurred in Jones Spring. The individual shown is 7 feet in length, with a shoulder height of 5 feet.

emerge at night to feed in forest edge areas. Living tapirs are browsers on aquatic and low-growing, terrestrial vegetation in forest edge, riverine forest or shrubby areas. When threatened, tapirs take refuge in water or in dense underbrush.

During the Pleistocene *Tapirus* ranged widely in North America, from Florida north to Pennsylvania and west to Missouri, Arkansas, southern Oklahoma and Texas to southern Arizona. There are several records from California and a single occurrence known from southwestern Oregon. This distribution indicates that Pleistocene North American *Tapirus* was a browser in temperate as well as subtropical forests. The record from Arizona and probably those from Jones and Boney springs, Missouri as well suggest that Pleistocene North American *Tapirus* frequented forested river valleys. A network of such forests, fostered and maintained under moister Pleistocene climates, probably accounts for the past distribution of tapirs in North America.

The tapir fossils from Jones and Boney springs are referred to the Vero tapir, *Tapirus veroensis* (Figure 14), on the bases of tooth size and limb proportions. *Tapirus veroensis*, named for a locality in Florida, Vero Beach from which remains of this species were first described, was much larger than living species but was smaller than the other Pleistocene species known from eastern North America, *Tapirus copei*.

Tapir remains have also been reported from a fissure deposit near Herculaneum, Jefferson County, Missouri. This is the same locality that also contained the only other record of alligator known from Missouri.

Order Artiodactyla

The order Artiodactyla includes a great diversity of living forms and includes some of our most familiar and useful animals. Included in this order are the pigs, hippopotamuses, camels, deer, giraffes, cattle, bison, antelopes, goats and sheep, and others less familiar.

Like the Perissodactyla, living and extinct artiodactyls, a term meaning even-toed, have a characteristic foot but one in which both the third and fourth toes are emphasized and the others reduced. Also like the Perissodactyla, the Artiodactyla are hoofed animals adapted to running. Among the artiodactyls, camels, deer, bison and musk oxen were important late Pleistocene inhabitants of western Missouri.

Though rare in Missouri, camels of the extinct genus *Camelops* are common as fossils elsewhere in western North America. *Camelops* was primarily a grazer but its long neck and legs gave it an advantage as an occasional browser as well. The camel remains recovered from Jones Spring provide only the second known record of camels from the state of Missouri, the other record being from Atchison County in the extreme northwestern part of the state.

Camelops is represented by six species in the Pleistocene of North America. These can be arranged into a small-size species group and a large-size species group. The Jones Spring form (Figure 15) belongs to the large-size group that includes *Camelops hesternus*, *C. huerfanensis*, *C. kansanus* and *C. traviswhitei*. The Jones Spring camel is not, on the basis of recovered specimens, *C. traviswhitei*, nor do these fossils compare with those described, inadequately, for *C. kansanus*. It is not possible, however, on the basis of the Jones Spring fossils, to assign this camel to one or another of the other two species and these fossil remains are not identifiable as to species.

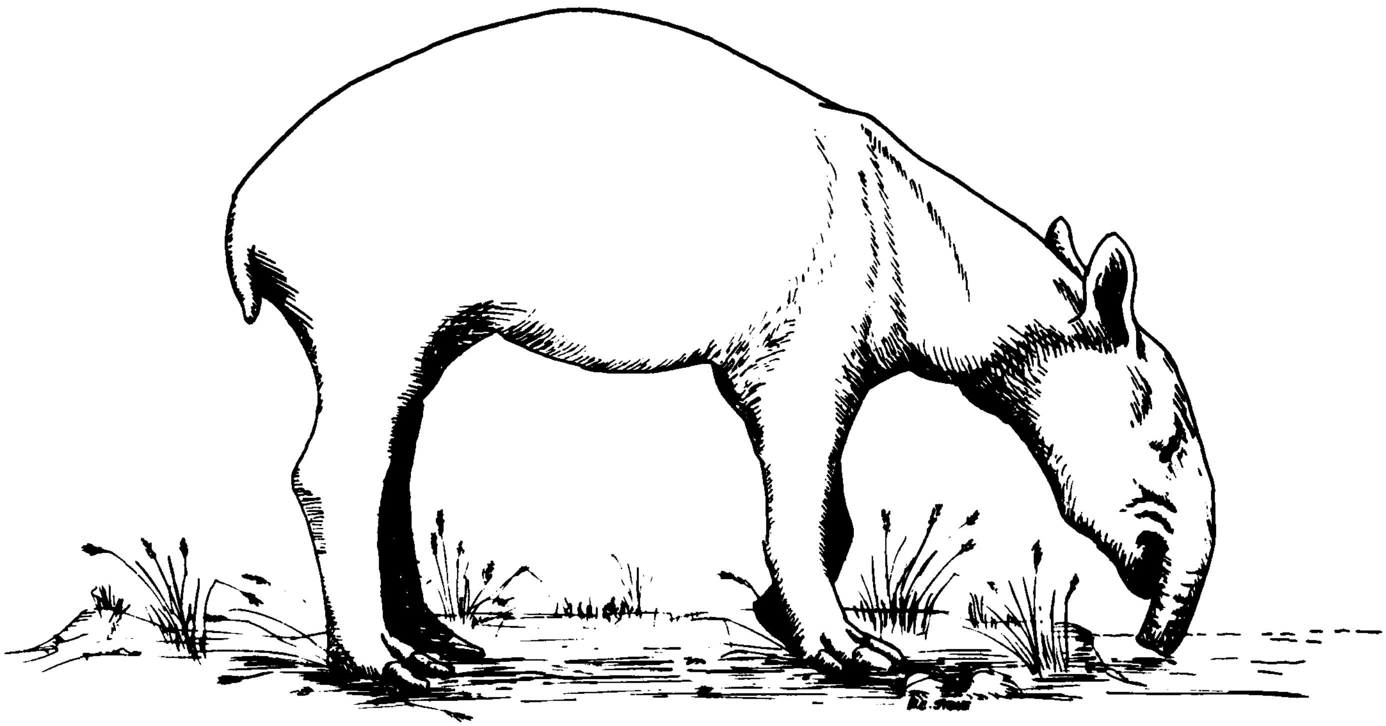

Figure 14. Vero tapir, *Tapirus veroensis*. Remains of the Vero tapir have been recovered from Jones and Boney springs. The individual represented is 8 feet in length, with a height at the shoulder of 3.5 feet.

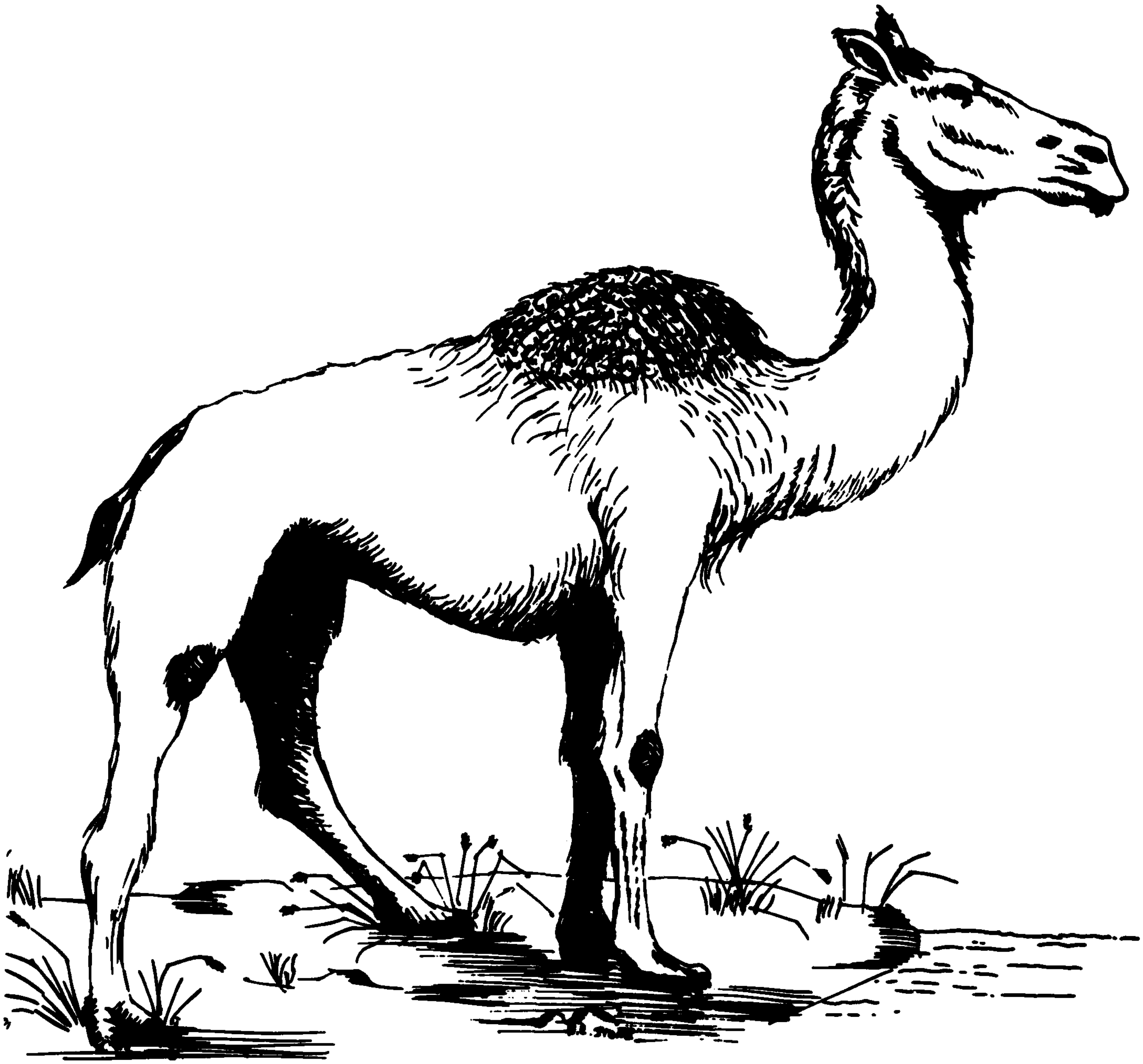

Figure 15. Extinct camel, *Camelops* sp. Camel fossils occurred in Jones Spring. *Camelops* contained several species of large, lama-like camels. Based on specimens found in Jones Spring it was not possible to identify with certainty which species was represented in western Missouri. The individual shown has a length of 9 feet and a height at the shoulder of 7 feet.

The Stilt-legged deer, *Sangamona fugitiva*, is one of the most enigmatic animals in the Pleistocene fauna of North America. The characters of this deer are still uncertain and the genus, which contains a single described species, has served as a "catch-all" for Pleistocene North American deer of a size intermediate between Mule or White-tailed deer and Elk. Similarly, very little is known regarding the preferred habitat of this animal. Fossils referred to *Sangamona fugitiva* recovered from the peat in Trolinger Spring, together with pollen evidence relating to environment, add appreciably to our understanding of the morphology and habitat of this poorly known deer.

Foremost in importance of the fossils from Trolinger Spring that are referred to the Stilt-legged deer is an antler fragment. Antlers of this deer have not previously been described and have hithertoo been unknown. The most complete skeleton of this animal known, from a cave in Pennsylvania, was anterless and presumably a female. The Trolinger Spring antler fragment is completely unique and quite unlike antlers in living or extinct North American deer for which antlers are known. The specimen was found near a tooth that can be referred to this species with good certainty on the bases of size and features of form. The proximity of this antler fragment to a tooth of *Sangamona fugitiva* as well as its unique shape make it highly probable that the antler is also assignable to *Sangamona fugitiva*. As can be seen in the accompanying illustration (Figure 16), the antler is a simple forked structure. In our reconstruction the top portions of the back fork, or major beam, are entirely hypothetical. The preserved portion of the antler includes both an anterior and a posterior fork or branch that diverge immediately above the base or burr of the specimen. The angle of this divergence measures 82°. Living Mule or White-tailed deer lack the anterior branch that is well developed on the Trolinger Spring antler. Whereas Elk possess this branch, their antlers are as a rule considerably larger, contain an additional branch in this basal region, and have, in every case observed by me, an angle of divergence of the two major branches measuring appreciably greater than 90°. Antlers of other known living (e. g., moose) or extinct late Pleistocene (e.g., Mountain deer, Stag-moose) North American deer are completely unlike the Trolinger Spring specimen.

Pollen associated with the fossils of *Sangamona fugitiva* in Trolinger Spring peat indicate that this deer inhabited an open pine-woodland. The Stilt-legged deer was presumably a browser.

Remains of extinct forms of bison are common Pleistocene fossils in much of North America, including Missouri. The bison record from spring sites in western Missouri is most notable for the occurrence in Jones Spring of abundant specimens, including a partial skull, that can with certainty be referred to Giant bison, *Bison latifrons* (Figure 17).

Bison latifrons is not a common fossil. The species is now known from 49 localities in the United States and from one locality in Mexico. It has not been reported from Canada or Alaska. Though probably never abundant, the Giant bison was most common on the Great Plains, in the Great Basin, along coastal California and in Florida. In addition, there are isolated records of this species known from Kentucky, Ohio and, now, Missouri. This distribution pattern suggests that *Bison latifrons* was probably both a browser and a grazer primarily adapted to forest openings or woodlands. The species became extinct perhaps 48,000 years ago but did give rise to later forms, including the ancestor of the living Plains bison, *Bison bison*.

Giant bison is, as the name implies, the largest species of fossil bison

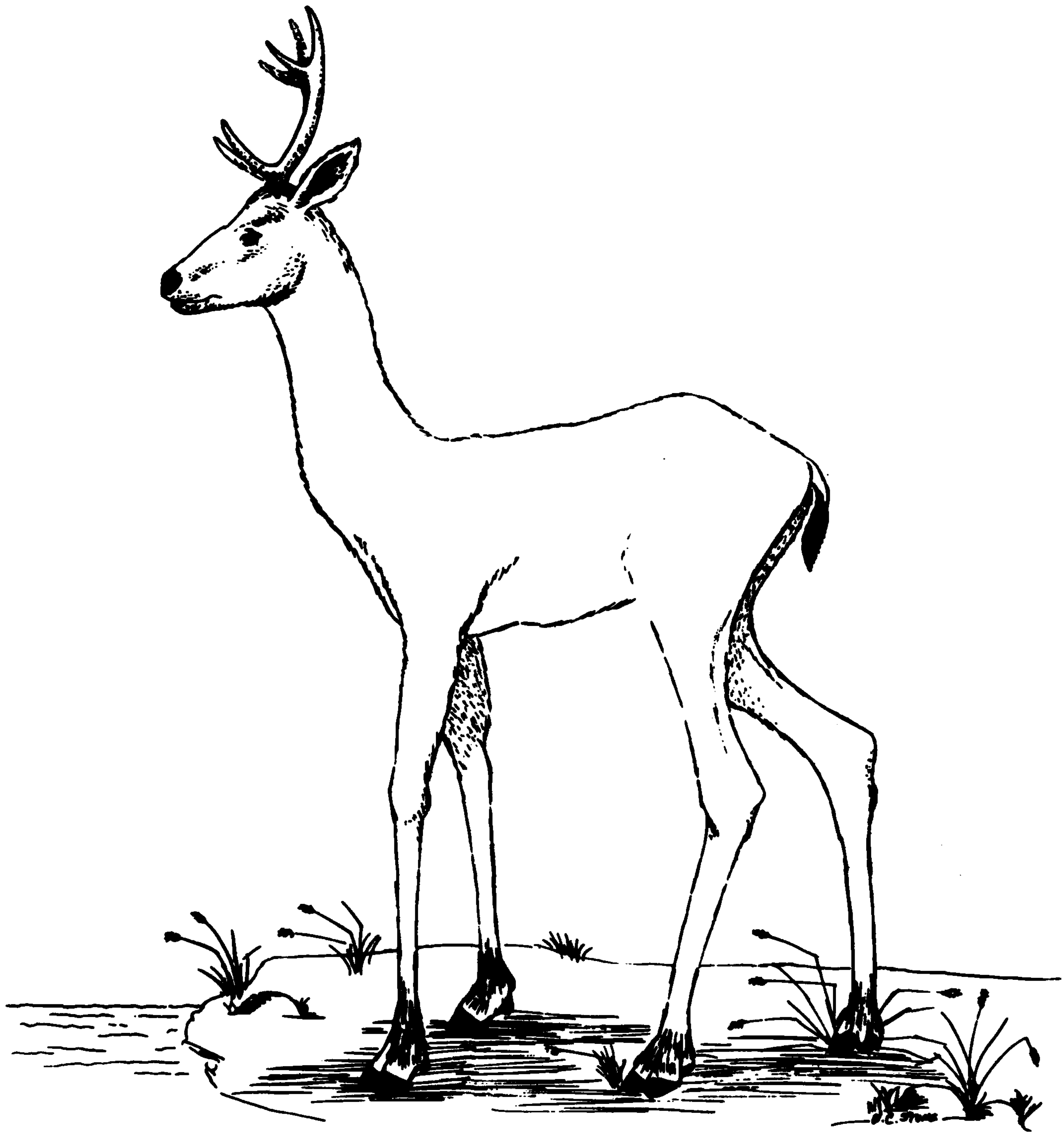

Figure 16. Stilt-legged deer, *Sangamona fugitiva*. Remains of *Sangamona fugitiva* were recovered from the peat in Trolinger Spring. The individual shown is 6.5 feet in length and has a shoulder height of 5 feet.

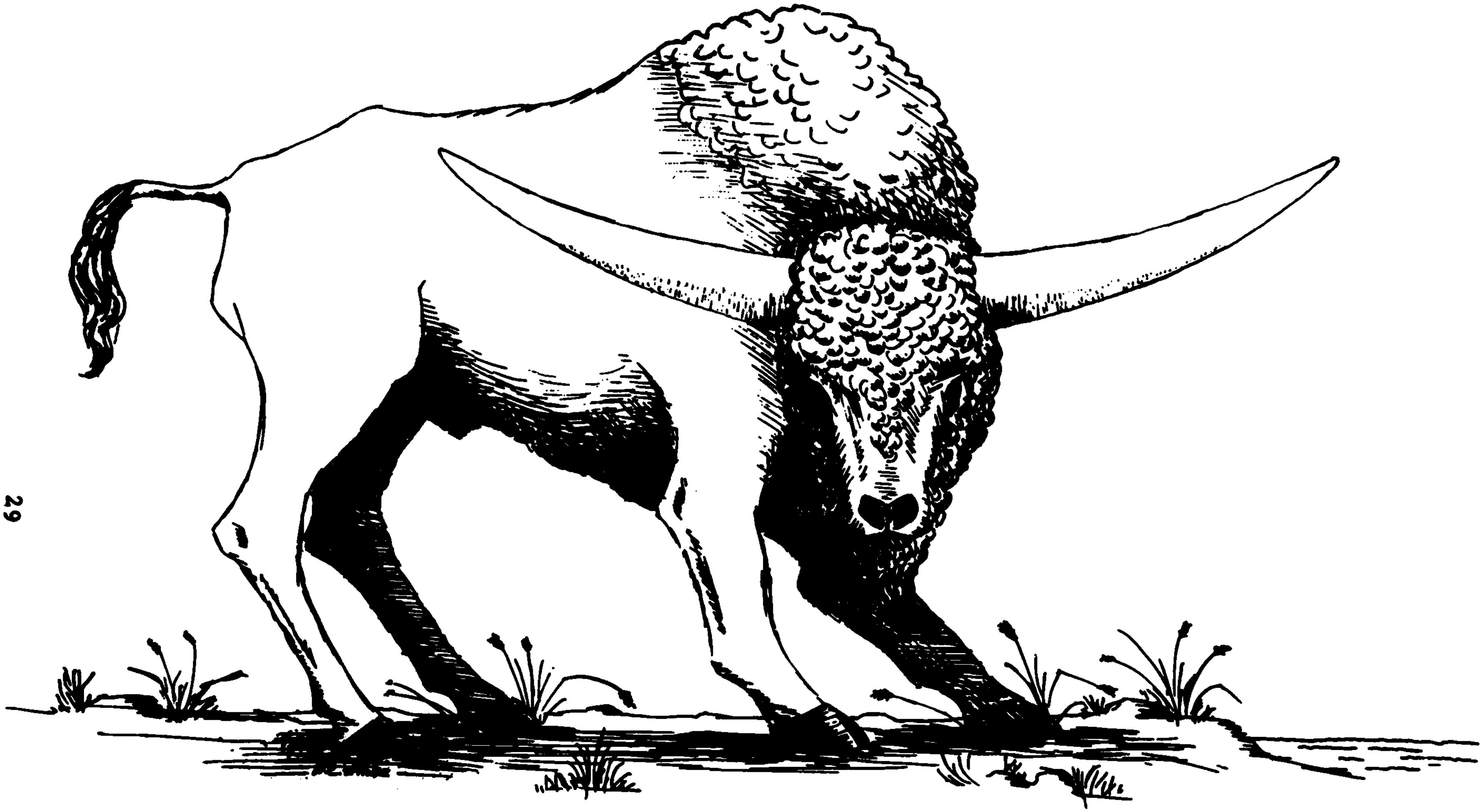

Figure 17. Giant bison, *Bison latifrons*. The Giant bison remains from Jones Spring represent the first record of this Pleistocene animal known from the state of Missouri. The horns of the individual represented measure 6 feet from tip to tip.

known to have existed, as inferred from the massive skull, immense horn cores and large skeleton that characterize this species. Large males of this species carried horns that easily extended over 7 feet from tip to tip. Nevertheless, *Bison latifrons* is the most poorly known of all species of North American fossil bison. This is due, presumably, to its relatively great antiquity and probably more or less solitary habits. The specimens from Jones Spring are thus important fossils that further our understanding of this poorly known species. In addition, the Jones Spring fossils were associated with plant fossils that allow the preliminary reconstruction of Giant bison habit. These suggest that this species did indeed inhabit deciduous forest openings or woodlands.

Additional bison remains occurred higher in the spring deposits in Jones Spring. These fossils are of a generally smaller form intermediate in size between *Bison latiforns* and Antique bison, *Bison antiquus*. *Bison antiquus* is thought to have descended from *Bison latifrons* and it appears that this transition is actually evidenced in Jones Spring. *Bison antiquus*, in turn, gave rise to the living Plains bison, *Bison bison* during the last 10,000 years. *Bison bison* remains were not recovered from any of the spring sites in western Missouri, which contained only older records.

The final animal to be considered here is the Woodland muskox, *Symbos cavifrons* (Figure 18). Closely related to the living Muskox, *Ovibos moschatus*, of northern Canada and Greenland, *Symbos cavifrons* differed in having a greater size, a different appearance and, perhaps especially, different habits. Fossil remains of Woodland muskoxen occur from Alaska south to Mississippi and from the Pacific to the Atlantic coasts, with most of the records known from the east-central United States, including Missouri.

Fossil specimens referred to *Symbos cavifrons* were recovered from Trolinger Spring. These materials include a partial skull and numerous teeth and their identification is certain. Muskoxen fossils were also recovered from Jones Spring. These specimens, however, do not include such diagnostic materials as skulls and are for this reason not identifiable as to the genus of species.

Symbos cavifrons has been previously reported from eastern and west-central Missouri. The Trolinger Spring specimens are, however, in terms of abundance and variety, currently the most important collection of Woodland muskox remains known from the state.

As seen from the illustration, *Symbos cavifrons* was a tall and lightly-built animal. One common name for this species is the Helmeted muskox which draws attention to the characteristic horns. These structures occur higher on the skull than those of the living Muskox. The horns curve outward, downward and forward in the extinct form. At the center of the skull, the left and right horns were actually fused as a single horn mass having the appearance of a helmet.

Pollen associated with the fossil remains in Trolinger Spring indicate that *Symbos savifrons* inhabited an open pine woodland where it was probably primarily a browser. Elsewhere in eastern North America this Woodland muskox appears to have inhabited coniferous forests or woodlands of spruce and fir in addition to pine. It was probably adapted to warmer conditions than is *Ovibos maschatus*.

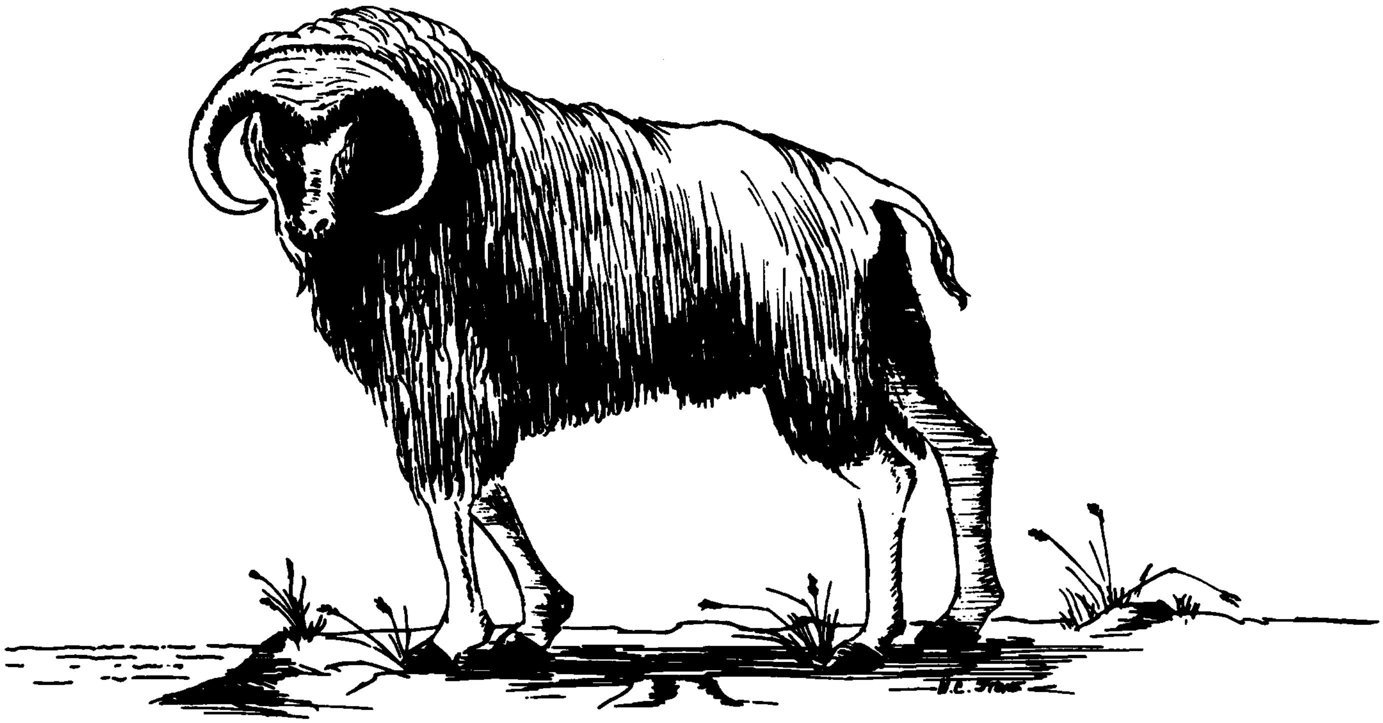

Figure 18. Woodland muskox, *Symbos cavifrons*. Woodland muskoxen were common late Pleistocene inhabitants of western Missouri. In western Missouri remains of *Symbos cavifrons* were recovered in the Trolinger Spring peat. Muskoxen fossils from Jones Spring are probably from this form as well. The individual shown has a length of 9 feet and has a height at the shoulder of 6 feet.

THE EVIDENCE

Jones Spring

Jones Spring is the oldest of the fossil localities in the project area from which a record of prehistoric life has been obtained. The majority of the fossil specimens (Table 1) occurred in the lower of two peat deposits. This stratum was 15 meters in diameter and over 1 meter thick. It overlaid a 4 meter by 7 meter spring conduit filled with gravelly sand and mixed sand and fine gravel in addition to white sand filling the spring's center or feeder. This peat deposit was separated by color and texture into an upper dark brown sandy zone and a lower light brown gravelly zone. Fossils also occurred at the contact of this peat with underlying gray clay. This gray clay formed the bottom and shore of the most ancient spring pond. From the positions of some of the fossils recovered from the zone of this contact, it can be inferred that this clay provided treacherous and hazardous footing for animals that ventured into the pond, some of which became mired and trapped there. The upper peat deposit was less extensive and not as richly organic. It contained many fragmented and rounded fossil specimens suggesting forceful redeposition from the lower peat. Apparently after the deposition and burial of the lower peat, spring discharge was vigorously renewed and a mixture of peat, gravel and sand as well as fossils was forced from the lower peat through clay into a higher and younger position. Here a smaller pond developed that underwent its own succession and in which peat developed and additional remains of animals accumulated.

TABLE 1

The late Pleistocene vertebrate fauna from Jones Spring, Hickory County, Missouri.

Taxon	No. of Specimens	Minimum No. of Individuals
Class Reptilia		
Order Chelonia		
Chrysemys scripta,		
Pond slider	1	1
†*Terrapene carolina putnami*,		
Extinct Box turtle	18	3
cf. *Terrapene carolina putnami*	>150	16
Trionyx sp.,		
Softshell turtle	1	1
Order Crocodilia		
Alligator mississipiensis,		

TABLE 1 (Continued)

Taxon	No. of Specimens	Minimum No. of Individuals
American alligator	8	2
Class Aves		
Order Aseriformes		
cf. *Anas carolinensis*, Duck	2	1
cf. *Aythya collaris*, Duck	1	1
indeterminable duck sp.	1	1
Class Mammalia		
Order Edentata		
†*Glossotherium harlani*, Harlan's ground sloth	6	1
Order Rodentia		
Geomys sp., Pocket gophers	1	1
†*Castoroides ohioensis*, Giant beaver	1	1
cf. *Microtus* sp., Voles	1	1
Order Carnivora		
Procyon lotor, Raccoon	1	1
†*Smilodon* cf. *floridanus*, Sabertooth	1	1
Order Proboscidea		
†*Mammut americanum*, American mastodon	244	25
†*Mammuthus jeffersonii*, Jefferson's mammoth	81	12
Order Perrisodactyla		
†*Equus complicatus*, Complex-toothed horse	154	10
?†*Equus calobatus* or *Equus hemionus*, Onager	7	1
†*Tapirus veroensis*, Vero tapir	2	1
Order Artiodactyla		
†*Camelops* sp., Camel	17	4
Odocoileus virginianus, White-tailed deer	3	2

TABLE 1 (Concluded)

Taxon	No. of Specimens	Minimum No. of Individuals
†*Bison latifrons*, Giant bison	36	5
†*Bison latifrons* and/or *Bison antiquus*, Extinct bison	50	4
†*Symbos* or *Bootherium*, Woodland muskox	25	4

† = Extinct form

Trolinger Spring

Two fossil assemblages occurred in Trolinger Spring. The earlier of these has been designated Trolinger Spring I and the later, Trolinger Spring II. Each of these reflects a distinctly different environment.

Trolinger Spring I

Trolinger Spring I fossils (Table 2) occurred in gravels comprising the conduit system in Trolinger Spring as well as in adjacent gray clay of the terrace deposits. Though Trolinger Spring I sediments and fossils are not yet dated, it can be concluded from stratigraphic evidence and from radiocarbon age determinations relating to the Trolinger Spring II fossil assemblage that the Trolinger Spring I fauna dates to before 35,000 years ago. Furthermore, based on the stage of evolution represented by the bison remains from this locality, which are large but smaller, it is probable that the Trolinger Spring I fossil assemblage is several thousands of years younger than that recovered from nearby Jones Spring, which contained remains of giant bison.

TABLE 2

The late Pleistocene vertebrate fauna from Trolinger Spring I.

Taxon	No. of Specimens	Minimum No. of Individuals
Class Reptilia		
Order Chelonia		
Chrysemys scripta, Pond slider	1	1
Class Mammalia		
Order Carnivora		
†*Ursus americanus amplidens*, Extinct Black bear	3	1
Order Proboscidea		

TABLE 2 (Continued)

Taxon	No. of Specimens	Minimum No. of Individuals
†*Mammuthus jeffersonii*, Jefferson's mammoth	15	5
Order Perissodctyla		
†*Equus complicatus*, Complex-toothed horse	65	4
†*Equus* cf. *scotti*, Scott's horse	5	2
Order Artiodactyla		
Odocoileus sp., Deer	3	3
†*Bison* sp., Extinct bison	26	5

† = Extinct form

The Trolinger Spring I fauna lacks mastodon, but it does include bear, mammoth, horses, deer and bison. Fossil wood recovered in association with these animal remains indicate that the spring was bordered by deciduous woodland or forest during this time interval. The Trolinger Spring I fauna may be contemporaneous with the pollen recovered from nearby Kirby Spring that suggest a landscape of grassland scattered with sparse trees which has been dated to greater than 38,000 years ago. As already mentioned, the Trolinger Spring I fossil assemblage is younger by perhaps several thousands of years than the pine-woodland recorded at Jones Spring from shortly after 49,000 years ago to sometime before 40,000 years ago.

Trolinger Spring II

Trolinger Spring II fossils (Table 3) occurred in three strata that either overlaid or were set within Trolinger Spring I sediments. Fossils comprising the Trolinger Spring II fauna were recovered in a bone bed from near the base of a dark brown peat deposit and were dispersed in an underlying mixed brown peat and white sand as well as in white sand and fine blue chert gravel filling the spring feeder. Sediments containing this fauna are dated between 20,000 and 35,000 years ago. Based on stratigraphic evidence, however, the actual accumulation of fossils probably took place between 29,000 and 34,000 years ago and may have been restricted to a relatively short interval withi' the early part of that period.

TABLE 3

The late Pleistocene vertebrate fauna from Trolinger Spring II.

TABLE 3 (Continued)

Taxon	No. of Specimens	Minimum No. of Individuals
Class Mammalia		
Order Insectivora		
Blarina brevicauda,		
Short-tailed shrew	2	1
Order Rodentia		
Peromyscus spp.,		
White-footed mice	2	2
Synaptomys sp.,		
Bog lemming	1	1
Order Proboscidea		
†*Mammut americanum*,		
American mastodon	323	15
Order Artiodactyla		
†*Sangamona fugitiva*,		
Stilt-legged deer	2	1
†*Symbos cavifrons*,		
Woodland muskox	56	4

† = Extinct form

The Trolinger Spring II fossils represent a browsing fauna including mastodon, Stilt-legged deer and Woodland muskox. Pollen associated in the peat with these remains indicate that this fauna inhabited an open pine-woodland landscape.

Boney Spring

The final accumulation of mastodons and associated animals (Table 4) and plants in spring sites in western Missouri is represented by the Boney Spring fossil assemblage.

TABLE 4

The late Pleistocene fauna
from Boney Spring, Benton County, Missouri.

Taxon	No. of Specimens	Minimum No. of Individuals
Class Ostracoda		
Potamocypris smaragdina	200	- -
cf. *Potamocypris illinoisensis*	4	- -
Cypridopsis sp.	50	- -
Candona crogmaniana	35	- -

TABLE 4 (Continued)

Taxon	No. of Specimens	Minimum No. of Individuals
Candona sigmoides	1	- -
Candona cf. *fluviatillis*	10	- -
Limnocythere reticulata	2	- -
Class Insecta		
cf. *Pterostichus*	2	- -
indeterminate Dytiscidae (Diving Beetle)	- -	- -
cf. *Helophorous*	- -	- -
cf. *Olophrum*	1	- -
indeterminate Scarabaeidae (Scarab Beetle)	- -	- -
indeterminate Curculionidae (Weevils)	2	- -
indeterminate Chrysomelidae (Leaf Beetle)	- -	- -
Class Osteichthyes		
indeterminate fish	11	2
Class Amphibia		
Order Anura		
Bufo sp.,		
Toad	10	4
Rana catesbeiana,		
Bullfrog	1	1
Rana sp.,		
Frog	8	2
Order Urodela		
Ambystoma opacum,		
Marbled salamander	1	1
Class Reptilia		
Order Squamata		
Eumeces cf. *fasciatus*,		
Five-lined skink	1	1
Carphophis amoenus,		
Worm snake	4	1
Diadophis punctatus,		
Ringneck snake	1	1
Lampropeltis triangulum,		
Milk snake	1	1
Storeria sp.,		
Brown snake	2	1
Thamnophis proximus or *Thamnophis sauritus*,		
Western or Eastern ribbon snake	1	1
Thamnophis sp.,		
Garter snake	6	1

TABLE 4 (Continued)

Taxon	No. of Specimens	Minimum No. of Individuals
Class Mammalia		
Order Insectivora		
Blarina brevicauda, Short-tailed shrew	28	4
Cryptotis parva, Least shrew	2	2
Scalopus aquaticus, Eastern mole	30	2
Order Edentata		
†*Glossotherium harlani*, Harlan's ground sloth	87	4
Order Lagomorpha		
Sylvilagus floridanus, Eastern cottontail	1	1
Order Rodentia		
Sciurus cf. *niger*, Fox squirrel	1	1
Marmota monax, Woodchuck	4	1
Tamias striatus, Eastern chipmunk	7	2
Glaucomys volans, Southern flying squirrel	4	1
Geomys bursarius, Plains pocket gopher	4	1
†*Castoroides ohioensis*, Giant beaver	3	2
Peromyscus cf. *leucopus*, Woodland white-footed mouse	21	6
Neotoma floridana, Eastern wood rat	3	2
Synaptomys cooperi, Southern bog lemming	5	2
Microtus pennsylvanicus, Meadow vole	3	1
Microtus ochrogaster and/or *Microtus pinetorum*, Prairie vole or Pine vole	16	4
Microtus sp., Vole	13	- -
Napaeozapus insignis, Woodland jumping mouse	1	1
Order Carnivora		
Procyon lotor,		

TABLE 4 (Concluded)

Taxon	No. of Specimens	Minimum No. of Individuals
Raccoon	1	1
Order Proboscidea		
†*Mammut americanum*,		
American mastodon	717	31
Order Perissodactyla		
†*Equus* sp.,		
Horse	1	1
†*Tapirus veroensis*,		
Vero tapir	5	2
Order Artiodactyla		
Odocoileus sp.,		
Deer	8	1

† = Extinct form

As has already been shown, Boney Spring deposits were a sequence of clays and peat. The fossils occurred in two strata. An extensive bone bed, without parallel in western Missouri, was contained in gray clay 4 meters below the present day land surface. At the base of this bone bed, approximately 5 meters below the present day land surface, large wood fragments of spruce and larch were recovered. Clumps of decayed moss, representing the remnants of what once was an extensive moss mat also occurred at this level. This decayed moss choked the spring feeder and contained, in addition to scattered vertebrate fossils, the remains of seeds, wood and invertebrate fossils, including insects.

Radiocarbon dates from the bone bed fall into two groups. The spruce wood recovered from immediately beneath the bone bed dated 16,500 years ago. Organic debris that filled the pulp cavities of two mastodon tusks from the uppermost portion of the bone bed dated 13,500 years ago. In addition, a radiocarbon date on the moss from the spring feeder was 16,200 years, from which we learn that by this time the moss mat had begun to dry, decay and be accumulated in the spring's feeder. As already mentioned, detailed study of the Boney Spring sediments and fossils suggests strongly that the bone bed accumulated during the latest portion of the 13,500-16,500 year interval during a stressful period of drought.

The invertebrate remains recovered from Boney Spring have a very modern species aspect and are, with the single exception of the possible occurrence of a northern species of beetle (cf. *Olophrum* sp.), have a present day distribution that includes Missouri. Similarly, the toad, frog, lizard and snake remains recovered from the clay surrounding the fossils in the bone bed are from species that occur today in Missouri. The mammal remains represent 21 genera including 22 species. Of these, three genera (*Glossotherium*, the Ground sloth; *Castoroides*, the Giant beaver; and *Mammut*, the Mastodon) and five species (*Glossotherium harlani; Castoroides ohioensis; Mammut americanum; Equus* sp., Horse; and *Tapirus veroensis*, Vero tapir) are extinct. *Napaeozapus insignis*, the Woodland jumping mouse, is a living form that does not occur

today in Missouri. *Microtus pennsylvanicus*, the Meadow vole, occurs in Missouri today but does not live in the Pomme de Terre River valley. In the Pomme de Terre River valley *Synaptomys cooperi*, the Southern bog lemming, approaches the southern limit of its distribution. In summary, then, the late Ice Age fauna of western Missouri 13,500 years ago had a strong modern aspect.

Pollen recovered from the dated tusk fillings is dominated by spruce but includes such deciduous forms as oak, willow, alder, poplar, elm and ironwood as well. From the evidence of radiocarbon dates and pollen types which reveal vegetation, the Boney Spring fauna is associated with the terminal Ice Age conditions in western Missouri.

Additional Springs

Two other spring sites remain to be briefly discussed. Each of these, excavated during the middle of the last century, contained a presumably rich fossil assemblage that was not adequately reported and that today cannot be reassembled for study.

Koch Spring

One of these, Koch Spring, was excavated in 1840 by Albert C. Koch, proprietor of the St. Louis Museum. According to accounts of his contemporaries Koch recovered a large amount of fossil material from this locality (Table 5). The remains of numerous mastodons were found associated with those of ground sloth, deer, elk and ox, the latter probably bison or muskox. We do know that Koch sold his extensive fossil collection here and in England and Europe in 1843. Much of his mastodon material, including a complete but misconstructed mounted skeleton, was purchased by the British Museum (Natural History). Nevertheless, much, perhaps most, of Koch's collection is left unaccounted for and its present whereabouts unknown.

TABLE 5

The late Pleistocene vertebrate fauna from Koch Spring, Hickory County, Missouri.[1]

Taxon	No. of Specimens	Minimum No. of Individuals
Class Mammalia		
Order Edentata		
†*Megatherium* sp.	?	?
†*Glossotherium harlani*, Harlan's ground sloth	49+	3
Order Proboscidea		
†*Mammut americanum*, American mastodon	300+	38e
Order Artiodactyla		
Odocoileus? (deer), Deer	?	?

TABLE 5 (Concluded)

Taxon	No. of Specimens	Minimum No. of Individuals
Cervus? (elk), Elk	?	?
†*Bison?* and/or †*Symbos?* (ox), Bison or Muskox	?	?

[1] data are from Harlan (1843), with generic inferences by J.J.S.
†= Extinct form

During the course of our research Koch Spring was reinvestigated. In 1971 a north-south test trench through the center of the spring exposed a brown peat deposit buried beneath 2.5 to 3 meters of gray clay. This peat overlaid an interbedded sequence of clay, sand and gravel, the two latter representing the ancient spring conduit. We found that the entire center of the spring had been disturbed by Koch and possibly by later excavations. Our excavations confirmed the occurrence of mastodon remains, a few fragments of identifiable bones and tusk, in the disturbed peat overlying the spring's conduit. However, we recovered no fossil specimens representing other animals. From this we conclude that Koch's and possibly later excavator's methods resulted in nearly complete recovery of what must have been an extensive bone bed. A radiocarbon date for the middle of the peat is 31,800 years. Gray clay beneath the peat dates at greater than 38,000 years ago. These dates suggest a degree of contemporaneity between the peats in Koch and Trolinger springs. Pollen analysis of the peat remaining in place outside the central area of the spring indicates that an open pine-woodland existed during accumulation of most of the peat, and presumably most of the fossil assemblage, in Koch Spring. Spruce pollen appears near the top of the peat, however, and probably indicates the development of cold conditions approximately 25,000 years ago.

Kirby Spring

Kirby Spring, located just west of Jones Spring, is the only other spring site in the Pomme de Terre River valley known to have contained fossil remains. It also falls into the previously excavated category. We know virtually nothing about the history of excavations and discoveries at this locality. We know that Albert Koch returned to the Pomme de Terre valley in the fall of 1840 and that he acquired additional fossils in the region. It is possible that he dug in Kirby Spring at that time. It is equally possible that Kirby Spring was dug by someone else after Koch's time and after it was learned that Koch had sold his collection of fossil teeth and bones for what was then a large sum of money. Our reinvestigation of Kirby Spring revealed that it was considerably disturbed. We learned from fragments of bone in the old backdirt piles that Kirby Spring did indeed once contain fossil remains. Like much of the Koch Spring collection, however, the present whereabouts of the fossils recovered from Kirby Spring are unknown.

Pollen analysis of the peat remaining in place at the margins of the spring indicates that a shift from pine and oak woodland to dominantly grasses was occurring during this period dated at greater than 37,000 years ago. Presumably Kirby Spring fossils, though their whereabouts are unknown to us today, would have been much like those recovered in the gravels at Trolinger Spring.

EPILOGUE

This then has been a look at the Ice Age climates, plants and animals of western Missouri as interpreted from fossil remains recovered from spring sites in the Harry S. Truman Project area dating to the interval from 50,000 to 13,500 years ago. It remains for us to examine, briefly, these events over the last 13,500 years.

Our latest spring site containing the remains of fossil animals and associated plants dates to 13,500 years ago. These fossils, recovered from Boney Spring, indicate that at this time the oak-hickory forest of today was developing under the influence of a general warming climate. This warming was widespread and caused the general melting of the glaciers that still occurred to the north and east.

These forests-favoring climatic conditions were not stable in Missouri, and the forest of 13,000 years ago did not endure to the present day without interuption. We know from records of plants and animals contained in deposits associated with habitation sites of prehistoric man in western Missouri that changes did occur. The major change within this more recent period occurred between 7,500 and 5,000 years ago. From deposits dating to this period has come a record of plant and animal remains that demonstrate that a warm, dry climate prevailed. During this period Missouri and much of adjoining central Illinois as well was occupied by a plains grassland. Unlike previous landscapes of this type, for example the one indicated in the gravels deposited in Trolinger Spring approximately 38,000 years ago, this more recent plains grassland was not inhabited by mammoths or horses. Mammoths, horses and numerous other large Ice Age animals had become extinct by 11,000 years ago. Nevertheless, such unexpected animals as Pronghorn antelope and Plains bison did inhabit Missouri during this most recent episode of grassland-favoring climate.

Excavations in the uppermost stratum at Boney Spring revealed a storage pit containing acorns and hickory nuts. From radiocarbon age determinations on these plant remains we know that this storage pit was dug and filled by native Missourians 4200 years ago. These plant remains indicate further that by that date oak-and-hickory containing forests had returned to western Missouri. It is this forest, now much altered by commercial timbering and farm clearing, that we see today in western Missouri.

The conclusion to be drawn today from this look at past climates, plants and animals in western Missouri is that the duration of one single set of climatic conditions, though predictable and familiar over many human lifetimes. is nevertheless short geologically speaking. Prehistoric evidence from the last 50,000 years demonstrates that climates and the environments that they fostered were episodic and subject to great change. It is this knowledge that allows us to see our present era as prehaps just another interstadial in what is a continuing Pleistocene.

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